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Grainless Phosphor Screens for TV Tubes and a Light Amplifier

By FRANK J. STUDER

A luminescent coating deposited as a grainless layer avoids the diffusely scattered light associated with a conventional powder phosphor in television tubes. Such transparent phosphor screens of zinc sulfide can be made by a vapor phase reaction as will be described. With a screen of this kind, higher resolution and contrast are possible. Phosphor layers produced in this way may also be used as light amplifying screens.

A CONVENTIONAL cathode-ray tube screen consists of powder phosphor settled on a surface of glass or other material. It is made up of small crystalline grains which make irregular contact with each other, and with the surface on which they are deposited. For such a screen it is always true that a certain fraction of any light which is incident upon it, or is produced in it, will be scattered from particle to particle, giving rise to an undesired diffuse background illumination. This is illustrated in Fig. 1. If the phosphor is deposited as a uniform (grainless) layer instead of powder, as will be here described, the diffuse scattering is absent, and higher contrast and resolution are made possible in a cathode-ray tube picture.

Superposed layers of this kind, with an appropriate activator in each layer, may have application in color television using a system in which penetration, and therefore color, is controlled by the voltage of the cathode-ray beam. Continuous sheets of phosphor should give considerably better color separation than superposed layers of granular powder.

Such a continuous layer phosphor screen also has advantages in applications which depend upon the response of a phosphor to an impressed electrical field, as in the case of the electroluminescent cell. Continuous, uniform thickness layers of material on which electrodes can be deposited make possible uniform fields over large areas. It was with a cell made in this way that single layer light amplification has been observed in the sense that the visible output of the phosphor with a d-c electrical field applied has more energy than is incident in the ultraviolet. With such a screen a low-intensity, projected image in the ultraviolet can be converted to a high-intensity image in the visible.

There are many obvious applications for screens with this basic characteristic and their wide use awaits a further improvement in the phosphor layer.

Presented on October 6, 1955, at the Society's Convention at Lake Placid, N.Y., by Frank J. Studer, Light Production Studies, Research Laboratory, General Electric Co., Schenectady, N.Y.
(This paper was received on February 25, 1956.)

Light Scattered From Cathode-Ray Spot

It may be of interest to consider briefly the effects of scattering in the cathode-ray spot where a focussed electron beam is incident on a phosphor screen. There are three distinct cases (with, of course, intermediate situations): (a) settled powder with negligible optical contact between the powder and the glass; (b) transparent phosphor layer with complete optical contact with the glass, outside surface smooth; and (c) grainless phosphor layer having complete optical contact with the glass, outside surface rough. The nature of the light pattern for these cases is indicated in Fig. 2. In (a) light is not only scattered and rescattered from particle to particle, but it is also reflected from the front of the glass face-plate back to the phosphor where it is diffused. This gives rise to a bright spot in the center of a much larger bright disk of low intensity. In (b) there is produced only the bright spot just the size of the incident electron beam. In (c) the light which is reflected from the front of the glass is scattered by the rough surface of the phosphor. This reflected light reaches a maximum at the critical angle so that a bright ring is formed having a sharp inside edge with the intensity decreasing gradually toward the outside. The advantage of the nonscattering screen (b) in cases where high resolution and detail contrast are required is apparent from these considerations.

Method of Producing Grainless Phosphor Screens

The obvious way to put down a clear continuous layer of the inorganic materials of which phosphors are generally constituted, is to evaporate them in a vacuum chamber. Zinc sulfide in particular, which is commonly used for cathode-ray tube screens, evaporates readily from a tungsten boat and condenses as a very clear coating on glass. However, up to the present, no method has been found for carrying out the proc-

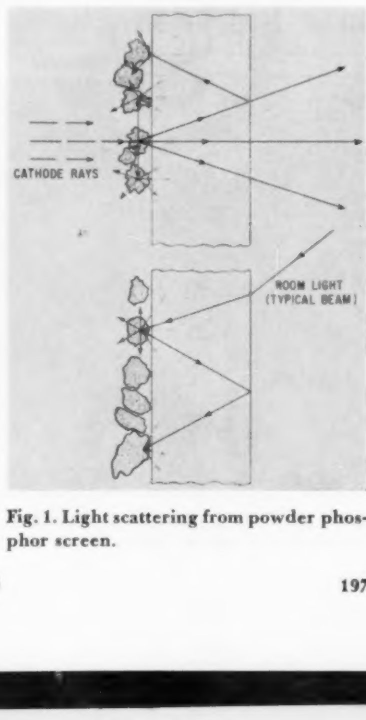

Fig. 1. Light scattering from powder phosphor screen.

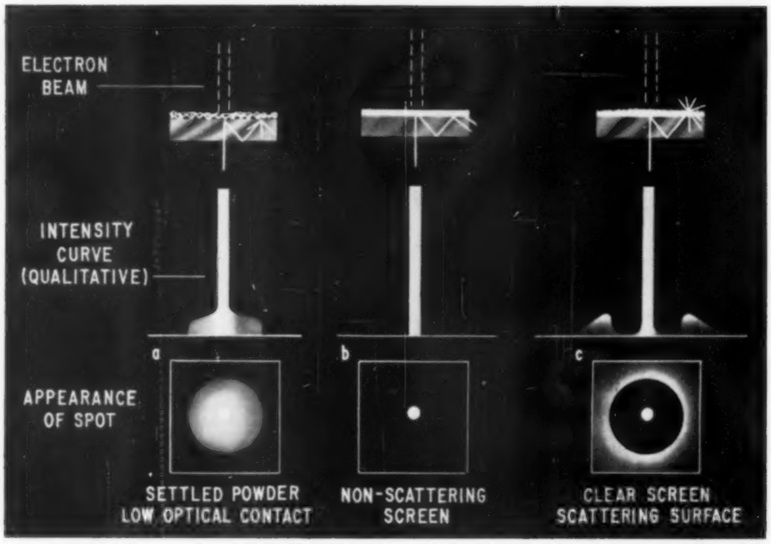

Fig. 2. Light pattern from cathode-ray spot on different types of phosphor screens.

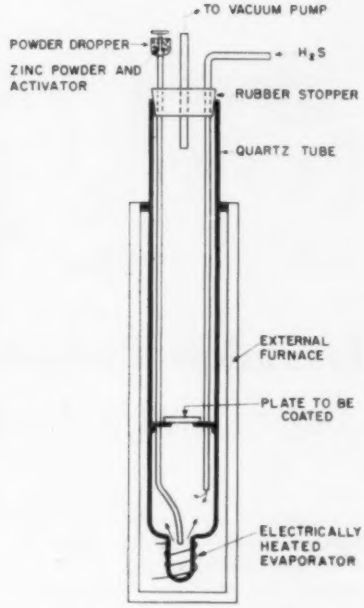

Fig. 3. Arrangement for making grainless ZnS phosphor screens by vapor reaction method.

ess without loss of most or all of the activator centers which give rise to luminescence.

The method developed at the General Electric Research Laboratory for making phosphor layers depends upon the reaction of the components in the vapor phase, at a heated surface, to form a glassy layer.[1] Thus the activator is incorporated as the phosphor is formed. For zinc sulfide the basic process is to bring together, at the surface to be coated, an atmosphere of hydrogen sulfide and the vapors of zinc or zinc salts, along with those of an appropriate activator.

The glass plate to be coated is supported in a quartz container which can be maintained at a temperature of 400 C to 700 C. The basic arrangement is shown in Fig. 3. The container is first evacuated, then H_2S is allowed to flow through at a low pressure. The components to be vaporized are introduced as a mixed powder. This is dropped a little at a time into the heated chamber, so that on the average the several vapor components will be continuously present in the same proportion. A typical powder mixture for making a screen of manganese-activated zinc sulfide is as follows: 25 g zinc powder, 12.5 g zinc chloride and 0.38 g manganese chloride.

For a given rate of introducing the powder, the thickness of the layer increases with the amount of material used. Under proper conditions the first deposit appears perfectly clear and smooth. As the thickness increases beyond the neighborhood of $\frac{1}{2}$ μ, the coating tends to develop a rough surface. This roughness increases with thickness and causes appreciable light scattering. However, this is largely a surface effect, so that when the surface is polished with a fine abrasive, transparency is generally restored in coatings as thick as 20 μ.

The layer of zinc sulfide produced in this way is very durable and so firmly bonded to the glass that it can be put through the same polishing operations as the glass itself. The screens will stand temperatures as high as 600 C in a dry atmosphere with essentially no damage. This suggests the possibility of making television tubes by sealing on a completed screen, rather than having to produce the screen inside the tube. Five-inch and 8-in. tubes have been successfully made in this way. The arrangement for doing this is shown in Fig. 4.

Activators in ZnS deposits made by vapor phase reaction that have been found to give relatively high response under cathode-ray excitation are manganese, copper, arsenic and phosphorus. Self-activated ZnS coatings can also be

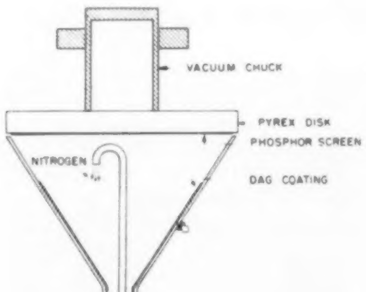

Fig. 4. Method of sealing completed screen to cathode-ray tube.

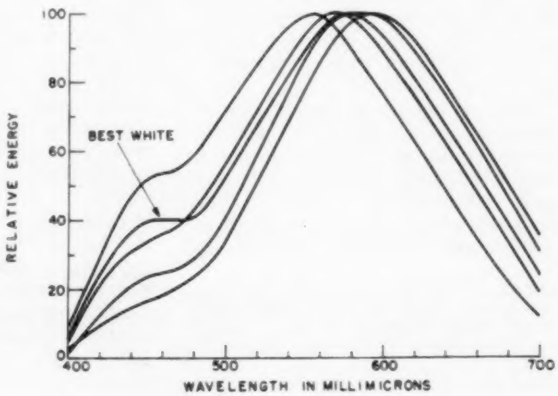

Fig. 5. Spectral distribution of luminescence for ZnS : As,P, made under different conditions.

made in this way. The emission spectrum in each case is in general the same as for corresponding powder phosphors.

For television viewing, of course, a white screen is required. The most satisfactory which have been produced have been made by using both arsenic and phosphorus as activators. The spectral emission obtained from coatings made under different conditions of temperature and H_2S pressure are shown in Fig. 5, and in it is indicated the most satisfactory appearing white. The spectral distribution is markedly different from the conventional white screen, but the color coordinates are reasonably close to the accepted color box for TV tubes.

In general, vapor reaction screens which we have been able to make are not as bright as powders of the same components fired at high temperatures. The best white emitting screens give in the neighborhood of 20-ft-L screen brightness for 1 μa/sq cm at 15 kv. Brightness voltage curves of typical white emitting transparent screens are shown in Fig. 6.

Electric Fields Applied to Solid Phosphor Layers Amplification of Incident Radiation

Layers of the phosphor ZnS : Mn produced by the vapor reaction method may be made to exhibit electroluminescence in alternating electric fields.[2] If the glass upon which the deposition is to be made has an initial transparent coating of TiO_2, this coating becomes electrically conducting as the zinc sulfide forms on it. Thus an electroluminescent cell can be made by evaporating or painting an electrode on the surface of the zinc sulfide. A cross section of such a cell is shown in Fig. 7.

It was while experimenting with a cell of this type, in which the phosphor layer consisted of ZnS : Mn,Cl, that D. A. Cusano[3] of this laboratory first observed the enhancement of luminescence by an applied d-c field, and in fact, demonstrated the amplification of incident radiation by such a field.[4]

If in the process of making a manganese activated ZnS coating by the vapor reaction process, $ZnCl_2$ is used along with zinc, the Mn and Cl become coactivators, with the result that the screen responds to near ultraviolet as well as cathode rays. With a cell then, made as shown in Fig. 7, when ultraviolet (e.g. 3650 A) is incident through the glass and the TiO_2 film, a yellow orange photoluminescence results. If now a d-c field is turned on (50 to 100 v for a film 10 μ thick, TiO_2 positive), the brightness is greatly increased (Fig. 8).

In a typical case, for low-intensity ultraviolet excitation (1 to 2 μw/sq cm), the amount of energy radiated in the visible, while the field is on, is 6 to 8 times as great as that in the incident ultraviolet. This amplification decreases in general, as the ultraviolet intensity becomes higher, the rate of decrease varying somewhat from sample to sample. In spite of this fact, such a screen can be used to produce from a projected ultraviolet image (Fig. 8) a visible image radiating more actual energy, area for area, than is incident on it while reasonable contrast is maintained.

These screens demonstrate the possibility of amplification of radiation in a single solid layer. As their characteristics are improved they will doubtless have many applications. The possibility of intensifying a low-energy image would simplify projection systems, reducing the required projection lamp wattage as well as permitting the use of simpler projection lenses of small aperture.

In a television system the circuitry could be greatly simplified if a low brightness image were sufficient on the picture tube. Since the electron beam then would have only to carry the picture informa-

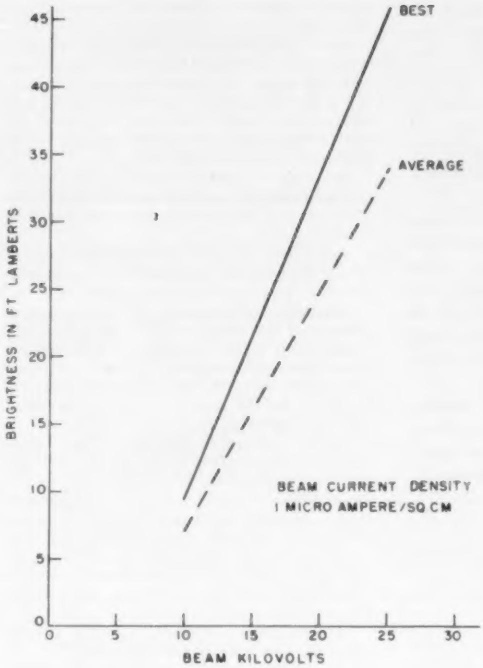

Fig. 6. Brightness voltage relation for typical ZnS : As,P, screens.

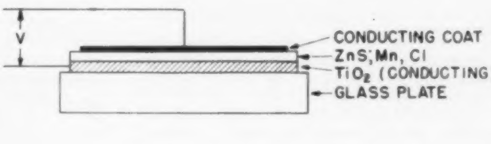

Fig. 7. Amplifying cell, cross section.

Fig. 8. Demonstration of enhancement of luminescence by an applied d-c field, with an ultraviolet image of TV test pattern projected on screen.

tion, the accelerating voltage could be much smaller than when the beam has also to produce a bright picture. The brightness could be brought to the required level by an amplifying screen which received a projected image, or which indeed was in contact with the phosphor on which the original image was produced.

The obvious way to use such a screen would be to let it directly replace the powder phosphor of the picture tube. For the films so far studied, however, the response of the cathodoluminescence to an applied field is very small compared with the ultraviolet-excited luminescence.

A screen of this type also lends itself to application in the field of X rays, where increased screen brightness with lower X-ray dosage is continually being sought.

References

1. F. J. Studer and D. A. Cusano, *J. Opt. Soc. Am., 45:* 493–497, July 1955.
2. R. E. Halsted and L. R. Koller, *Phys. Rev., 93:* 349–350, Jan. 1954.
3. D. A. Cusano, *Phys. Rev., 98:* 546–547, Apr. 1955.
4. F. E. Williams, *Phys. Rev., 98:* 547–548, Apr. 1955.

Discussion

Anon.: Does this have any persistance? If you change or move the image on the surface does the radiation from the source change accordingly?

Dr. Studer: These particular films do have considerable persistence the magnitude of which varies somewhat with the conditions under which they are made. If I set the voltage at 90 and switch it on and off you will see that it takes a noticeable time for the brightness to reach a maximum and then to decay. If however I have an initial voltage of 30, say, which causes very little enhancement, and then switch on an additional 60 volts, the brightness build-up and decay are much shorter.

Anon.: In other light amplifiers that we've seen, where it was from visual luminosity to visual output, you move the picture as you might in a movie and it would not move that rapidly on a screen. This doesn't have that limitation? In other words if you just moved the projector would the image move along with it?

Dr. Studer: With this screen as you can see when I move the projector there is appreciable persistence of the picture after the projected image is moved.

Anon.: Does it look fundamental in the function of the thing or is it something that can be corrected?

Dr. Studer: Since it has been found that the persistance of the phosphor layer varies with the conditions of preparation, there is hope that the decay time can be reduced to a satisfactory value. At present, however, the factors which are responsible for the persistence are by no means clearly understood.

Harold Schroeder, Jr. (*Bausch & Lomb Optical Co.*): What pressures do you have at the time you are depositing the zinc sulfide layer?

Dr. Studer: This may vary over a considerable range. We have made most of our deposits between 200 and 2000 microns pressure of H_2S. As I pointed out in connection with the slide showing spectra, the resulting spectral distribution depends somewhat on the pressure at which the coating was made.

Mr. Schroeder: In a range of from 200 to 2,000 microns, what is the rate of deposition?

Dr. Studer: That depends on the rate at which the materials are dropped in. The reason for dropping the materials as powders is to avoid the formation of surface layers on the evaporating material which would prevent the different components from coming out at the same time. By continually dropping small amounts of powder, the atmosphere at the plate where the coating is deposited is kept fairly consistently constant. It takes about ten minutes to make one of these coatings in our experimental setup.

Mauro Zambuto (*Transound Inc.*): Again on the question of the inertia of this layer to respond to electrical stimuli, did you say that above a certain threshold voltage the response of the layer is quite prompt?

Dr. Studer: This is true.

Dr. Zambuto: Did you make any measurement as to its speed? What I have in mind is an electrooptical light modulator. If the inertia to electrical stimuli is low enough, this device could modulate light over the audio range of frequencies. This could be used in motion-picture sound recording.

Dr. Studer: We have so far made only preliminary investigations bearing on this. The samples we have looked at would not be promising for this application. But here again we know that the time constant changes with different samples and it is to be hoped that when the cause for this is understood it will be possible to bring the decay time where we would like to have it.

Dr. Zambuto: You spoke of definition versus graininess of the zinc sulfide layer. How does the definition obtainable on this screen compare with the definition of the television image?

Dr. Studer: My impression is that the quality of of the television picture we get is not good enough to show up the potentialities of the transparent screen. They do promise to be useful in certain special applications.

I brought along one of our tubes for you to examine although I am not set up to put a picture on it. You will see that the face has the appearance of a mirror. This results from evaporating aluminum directly on the vapor reaction deposit of zinc sulfide. The annoying specular reflection is completely stopped by an anti-reflection polarizing filter, so that the blacks are really black even in a well lighted room. This is in contrast with a powder screen for which the anti-reflection filter would not work well, because of the degradation of polarization on reflection from the powder. Of course, the anti-reflection filter does reduce the light from the screen.

D. Lisle Conway (*General Electric Co.*): In using visual excitation, will the phosphor screen react to cathode-ray bombardment? Can you increase the light output by use of an electron gun?

Dr. Studer: The phosphor layers we have tried do not show nearly as great a response to an electric field when excited by cathode rays as when excited by ultraviolet. The behavior under cathode rays when a field is applied is not simple.

Mr. Conway: Is the rate of response fast enough to follow the trace of an electron gun such as that applied in the flying-spot scanner tube?

Dr. Studer: I'm sure not for any of the typical samples we have studied.

Colorimetry, Film Requirements and Masking Techniques for Color Television

By H. N. KOZANOWSKI and S. L. BENDELL

Increasing use of film for color telecasting has emphasized the need for a more critical view of the capabilities of both the film and the TV system, and for a greater understanding of the colorimetric behavior of the combination. Film and TV picture requirements are considered introductory to the principles of improved masking techniques.

Color television, even at this early stage of its commercial life, has already demonstrated that pictures of excellent quality can be obtained from color film. It is very probable that more and more programs and commercials will use color film in the future. The trend may well parallel a pattern which has been established in monochrome television where a substantial number of top-rating network programs originate on 35mm film.

However, the broadcaster needs assurance that excellent reproduction quality can be obtained in color television from film consistently and predictably under controlled production conditions. Only then does he dare to trust color film to carry any appreciable portion of his color broadcasting schedules. It may, therefore, be rewarding to take a critical view of the capabilities of color film and the color television system. The important factors governing the combined performance can be outlined to assist in obtaining high and constant standards of color picture quality. Detailed analysis of the various elements influencing system behavior has received the attention of many investigators.[1,2]

Basic Film Requirements

We can tabulate the main factors which should be under control as a background for our primary purpose, the discussion of the colorimetric behavior of color film and the color television system working together.

(1) Contrast range on the print should be restricted to a maximum of 20: 1 in terms of diffuse densities by careful control of lighting, composition, reflectance and processing; outdoor shots should be carefully planned to avoid the usually encountered high range in final prints.

(2) Wide and sudden shifts in film density should be avoided wherever possible.

(3) The color content should be planned carefully so as to avoid small and busy detail which would be lost in normal television viewing. Reflectance of high chroma areas should be as high as possible.

(4) Color should be as highly saturated as the mood to be portrayed will permit.

(5) Skin tones should look lifelike and pleasing on direct projection.

(6) Processing quality should be high and uniform within and between prints, especially in a sequence.

(7) Monitoring of color television should be done at standardized color temperature conditions so that consistent results will be obtained from all stations in a given area. This color temperature is indicative of what the home viewer can see on a properly adjusted and balanced receiver.

Color film prepared in accordance with these "Rules of Good Practice" may be described as "technically adequate." The use of such lukewarm praise can be appreciated by those who are directly involved in creating high-quality color entertainment utilizing the full capabilities of color film and color television techniques.

Basic Requirements for a Color TV Picture as Seen on a Color Display

It has been observed that the present-day television viewer expects to see color and plenty of it in the picture. We can assume that such color exists in the print. Experience appears to indicate that in television presentation an increase in the color saturation beyond what is on the print appears desirable. Techniques such as electronic masking have been developed as a means of increasing the saturation of color television pictures. At this time it is of no great concern whether masking is introduced to cancel dye crosstalk in film or for other technical reasons. It also becomes readily apparent that masking must be used with discretion if we are to produce better and not merely gaudier color pictures.

We come now to an observation which is becoming practically universal in the color television fraternity. Skin tones are of primary importance. The ability to reproduce skin tones pleasingly is one of the most important requirements of a color television system.

Even though one is at first driven away from any index of quality based on such a vague and subjective evaluation as "pleasing skin tones," it is encouraging to note that competent operators using standardized color monitors can bracket "pleasing skin tones" very closely without being able to define the criterion explicitly. The techniques are probably adequate to assure highly acceptable quality for the lay viewer.

Masking as a Tool for Picture Improvement

In any masking approach to increasing color picture saturation one finds that an increase in saturation will, in general, affect skin tone rendition. Thus, any print in which skin tones are too red, green, blue or another hue on even mildly critical direct viewing will go much more in the same direction with electronic masking. The problem then is to determine whether practical methods are available to provide controllable increase in color saturation and also to make possible the correction of skin tones.

There are several approaches which have been explored with varying degrees of success. They can be divided into processing the three simultaneous red, green and blue signals or the variation of subcarrier amplitude and phase in the colorplexed or encoded signal.

It is only fair to point out that bad color film stays bad after any of these treatments and that the technique is essentially a vernier to improve good film. Subjective direct-projection viewing of the film serves as an index of probable quality to be obtained through a television system.

There are three general cases in which it would be advantageous to operate on the video signals.

(1) The color film saturation is high or adequate, but the skin tones are off slightly. Here, one would like to maintain saturation but correct skin tones only.

(2) Film saturation is low, and masking, used to improve it, may cause skin tones to depart from pleasing values. At lower saturations this departure may be small, but is emphasized if any large degree of masking is used.

Presented on October 6, 1955, at the Society's Convention at Lake Placid, N.Y., by H. N. Kozanowski (who read the paper) and S. L. Bendell, Bldg. 10-3, Commercial Electronic Products, Radio Corp. of America, Camden 2, N.J.
(This paper was received on February 21, 1956.)

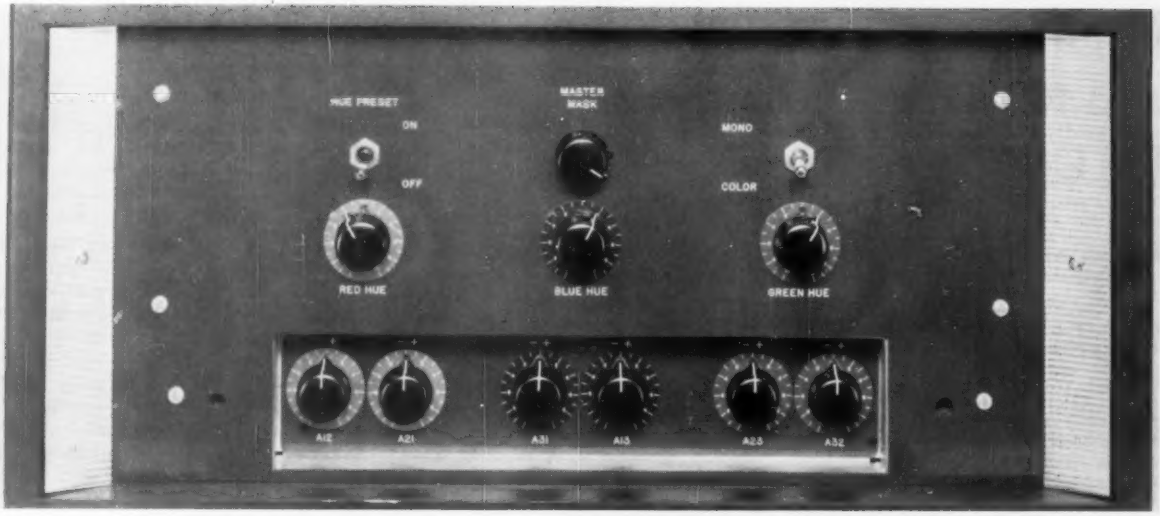

Fig. 1. Front view, showing operating controls, of Masking Amplifier (MI-40525).

(3) In a commercial or an abstract without any skin tones to serve as an index, it may be desirable to "paint" the picture in glowing colors.

Skin tone departures from the ideal may be constant throughout a reel or a print, or may vary from scene to scene depending on lighting, and on scene content. These possibilities have great influence on the operational requirements of any proposed correction device.

Early Approaches to Masking

In May 1955 we demonstrated at the NARTB Washington Convention a masking amplifier which had been developed as an extension of earlier work at RCA and NBC. It followed standard cross-matrixing theory and circuit developments, contained automatic white balance circuitry and provided calibrated dials on which any required masking coefficients, both positive and negative, could be set up directly as indicated by the Eastman, Ansco, Technicolor or other film requirements. This model also contained preliminary circuits for hue control following the general approach outlined by Brewer, Ladd and Pinney before the Institute of Radio Engineers in March 1955. Our advanced development model also contained a single-knob control which varied the saturation of all components simultaneously from the "no masking value" to a preset maximum.

Demonstrations at NARTB were given to a large number of broadcasters to obtain their reactions to the possible usefulness of such a device if it were made available commercially. The reaction was that the single-knob feature was a worthwhile step in providing an easy way of introducing masking according to a preselected correction pattern. The degree of masking, which various operators introduced for similar slides, was close enough to provide duplicable results.

Improvements in Masking Amplifier Techniques

In the opinion of more experienced and critical viewers the single-knob control, while ideal from the simplicity standpoint, might be too rigid operationally. They observed that it does not offer the possibility of skin-tone correction without varying the six preselected calibrated masking control knobs. While such variation is possible in principle and even in practice where complexity of procedure and time required is unimportant, we were driven from this consideration by the fact that it is possible to get thoroughly "lost" in the maze of masking combinations without developing any systematic or logical approach to the problem of skin-tone correction.

As was previously mentioned, the "black-box" masker included circuits for hue controls as proposed in a paper[1] by Eastman Kodak Co. These "Brewer, Ladd and Pinney" hue control knobs were hidden in the equipment and were not publicly demonstrated. However, Messrs. Brewer, Ladd and Veal spent some time with us discussing the operation of the hue controls and resolved some apparent discrepancies between theory and observation. This resulted in further circuit modifications and refinements and brought out the need for additional field testing.

The masker is shown in Figs. 1 and 2. Figure 1, the front panel, shows the six independent coefficient control knobs (A_{12}, A_{21}, etc.) located in the recessed well. These are controls that would be set up to give best results with the widest extremes of film to be handled. As such, they are not operating controls and are generally under cover. The three hue controls add or subtract to the coefficient values set up by the recessed "A" knobs. These are operating controls and are used to effect slight modifications of skin tones or other hues. All three hue controls are rendered inoperative by turning off the Hue Preset switch. This enables the operator to set up the three hue knobs to predetermined values without affecting the "on-the-air" picture. The master masking knob functions as an overall saturation control. It sets up a multiplying factor ranging from 0 to 1 by which all coefficients (set up by any combination of "A" knobs and Hue knobs) are multiplied. Complete counter-rotation of this control removes all masking.

The Mono-Color switch serves as a checking means to insure that the unit is maintaining exact white balance under all conditions of masking. By simply feeding the green signal to all channels of the masking amplifier one simulates a monochrome signal.

The chassis view of the masker is shown in Fig. 2. The three output stages are feedback pairs, and together with current stabilization techniques assure stable operation and constant white balance.

Our laboratory observations have shown that at this stage of development the new masker has the required flexibility to enable an operator to make worthwhile corrections in skin tone as well as to increase color saturation.

Conclusions

Demonstrations to network engineering representatives using slides and film were made. Again the general potentialities were verified, but there were some misgivings expressed regarding the ability of operators to acquire the necessary intuition or judgment as to which Hue knob to turn in order to correct a specific skin-tone error.

Recent extensive telecasting of color film using this masker for both increased saturation and color correction has given us more optimism regarding the ability to acquire a straightforward operating

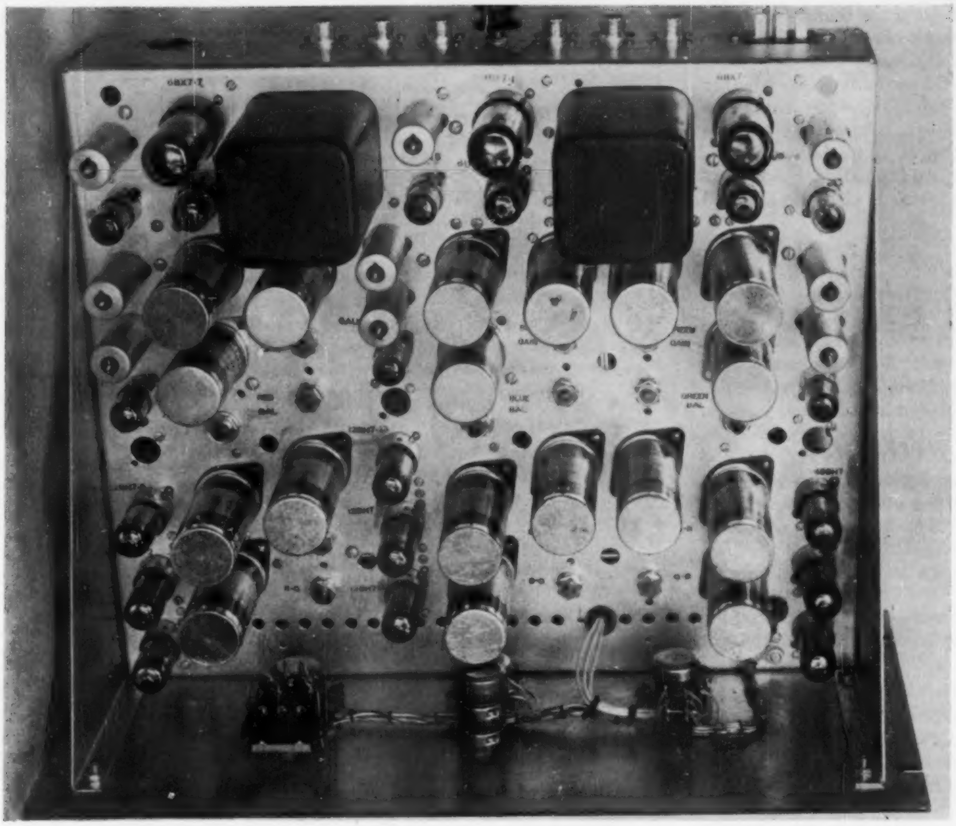

Fig. 2. Top view of chassis, showing tubes and circuit arrangements, of the Masking Amplifier.

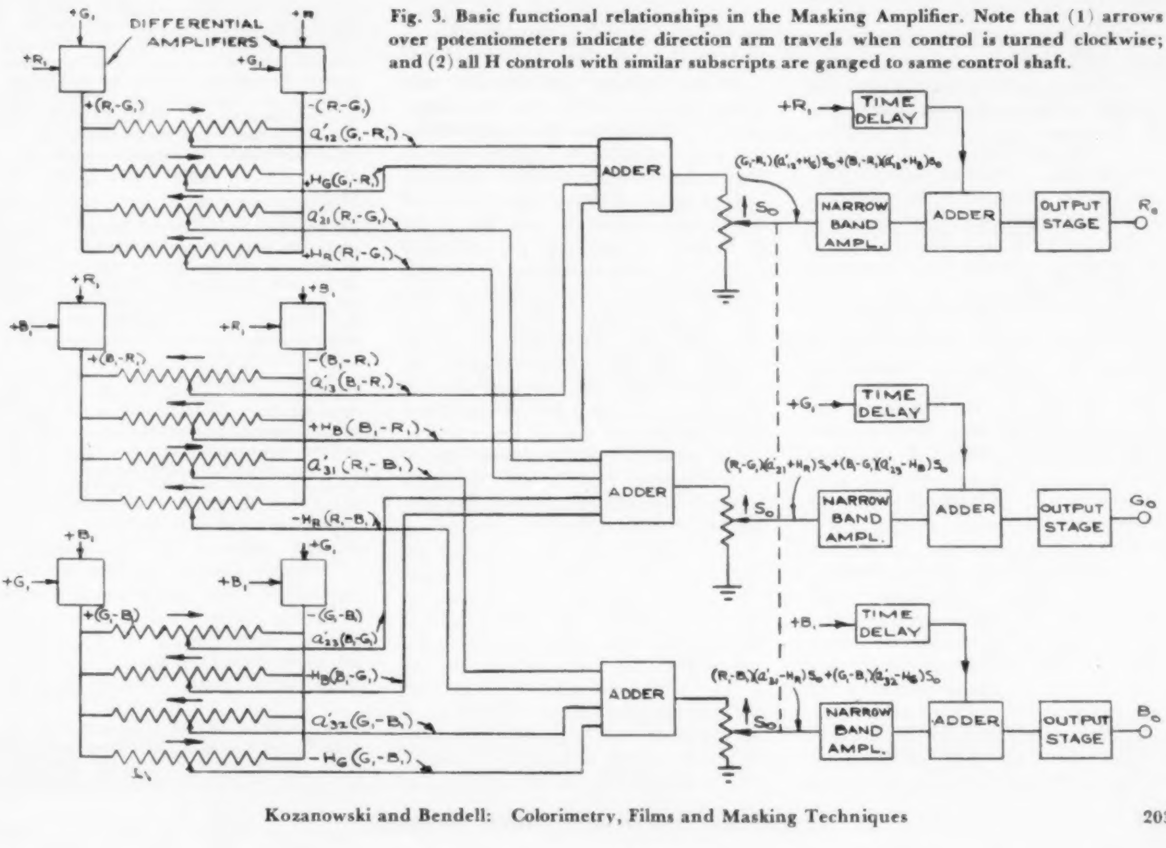

Fig. 3. Basic functional relationships in the Masking Amplifier. Note that (1) arrows over potentiometers indicate direction arm travels when control is turned clockwise; and (2) all H controls with similar subscripts are ganged to same control shaft.

technique. Reports are that a creditable job can be done on correcting film under "On-Air" conditions.

It is still a bit too early to say whether this masker and skin-tone correction approach presents a long-term solution to the problem of improving color film reproduction. Additional operational experience will certainly yield the required evaluation.

References

1. W. Lyle Brewer, J. H. Ladd and J. E. Pinney, "Brightness modification proposals for televising film," *Proc. IRE, 42:* 174–191, Jan. 1954.
2. Donald G. Fink, "Color Television vs. color motion pictures," *Jour. SMPTE, 64:* 281–290, June 1955.

APPENDIX

The general masking equations as normally written are:

$$R_0 = (1 - a_{12} - a_{13}) R_1 + a_{12} G_1 + a_{13} B_1 \quad (1)$$

$$G_0 = a_{21} R_1 + (1 - a_{21} - a_{23}) G_1 + a_{23} B_1 \quad (2)$$

$$B_0 = a_{31} R_1 + a_{32} G_1 + (1 - a_{31} - a_{32}) B_1 \quad (3)$$

where R_1, G_1, B_1 represent the three gamma-corrected camera signals before masking, and R_0, G_0, and B_0 are the masking amplifier output signals, matrixed and suitable for insertion into a colorplexer or encoder.

These equations contain six independent masking coefficients and satisfy the requirements for maintaining white balance.

As suggested by Brewer, Ladd and Pinney, hue shifts may be accomplished by the simultaneous changing of two of the appropriate coefficients according to the following table:

Colors Affected	*Coefficients to Be Changed*
Colors lying on red-cyan axis	Increase a_{21} — decrease a_{31} *or* Decrease a_{21} — increase a_{31}
Colors lying on green-magenta axis	Increase a_{12} — decrease a_{32} *or* Decrease a_{12} — increase a_{32}
Colors lying on blue-yellow axis	Increase a_{23} — decrease a_{13} *or* Decrease a_{23} — increase a_{13}

The details of this technique were presented in a paper by Brewer, Ladd and Pinney before the I.R.E. in March 1955.

Equations (1), (2) and (3) may be rewritten as:

$$R_0 = R_1 + (G_1 - R_1) a_{12} + (B_1 - R_1) a_{13} \quad (4)$$

$$G_0 = G_1 + (R_1 - G_1) a_{21} + (B_1 - G_1) a_{23} \quad (5)$$

$$B_0 = B_1 + (R_1 - B_1) a_{31} + (G_1 - B_1) a_{32} \quad (6)$$

For convenience in constructing the masking unit and illustrating its compliance with the Eastman recommendations:

$$\begin{aligned} a_{21} &= a'_{21} + H_R \\ a_{31} &= a'_{31} - H_R \\ a_{13} &= a'_{13} + H_B \\ a_{23} &= a'_{23} - H_B \\ a_{12} &= a'_{12} + H_G \\ a_{32} &= a'_{32} - H_G \end{aligned}$$

where the H's are incremental additions to or subtractions from the associated a's.

To indicate the function of the "one-knob" overall saturation control, each coefficient (a_{12}, a_{21}, etc.) is multiplied by a factor S_0 which is always positive and ranges in value from 0 to 1.0. The final masking coefficients now become:

$$\begin{aligned} a_{21} &= (a'_{21} + H_R) S_0 \\ a_{31} &= (a'_{31} - H_R) S_0 \\ a_{12} &= (a'_{12} + H_G) S_0 \\ a_{32} &= (a'_{32} - H_G) S_0 \\ a_{13} &= (a'_{13} + H_B) S_0 \\ a_{23} &= (a'_{23} - H_B) S_0 \end{aligned}$$

Rewriting the entire masking equations gives:

$$R_0 = R_1 + (G_1 - R_1)(a'_{12} + H_G) S_0 + (B_1 - R_1)(a'_{13} + H_B) S_0 \quad (7)$$

$$G_0 = G_1 + (R_1 - G_1)(a'_{21} + H_R) S_0 + (B_1 - G_1)(a'_{23} - H_B) S_0 \quad (8)$$

$$B_0 = B_1 + (R_1 - B_1)(a'_{31} - H_R) S_0 + (G_1 - B_1)(a'_{32} - H_G) S_0 \quad (9)$$

In the masking amplifier the "H" knobs are arranged to give zero incremental coefficient change at mid-position and may go positive or negative, depending on direction of rotation.

It is apparent that if the H's are all set to mid-position or zero, and if the S_0 is made to equal 1.0, the calibrated "A" knobs on the masker are direct reading and relate directly to the a's in Eqs. (1), (2) and (3), and (4), (5) and (6). The masker is constructed so that if the S_0 knob is turned up fully clockwise, $S_0 =$ 1.0 and the "A" knobs are calibrated to read from −1.0 to +1.0, being zero at mid-position.

Full counterclockwise rotation of the S_0 knobs makes $S_0 =$ zero and effectively removes all masking, making $R_0 = R_1$, $G_0 = G_1$ and $B_0 = B_1$.

A block functional diagram of the masker, Fig. 3, indicates how the various relationships are obtained.

Discussion

Thomas T. Goldsmith, Jr. (Du Mont Laboratories): Do you notice any difference in the masking advantages when you are operating on a signal originating through a flying-spot scanner or rather a linear photocell as compared with that of operating on signals from an image-orthicon or vidicon system?

Dr. Kozanowski: Fundamentally the only difference that we can notice in this respect, assuming that the colorimetry has been picked adequately for both systems, is a matter of signal to noise. I think from that point of view we are reasonably lucky in being able to get high signal-to-noise ratio out of the vidicon without trying to work too hard for the privilege. From that point of view, one has more latitude in masking and gamma correction without being hemmed in by the other requirements.

Dr. Goldsmith: Particularly, is there any difference in the linearity between those two methods that influences the success of the masking technique?

Dr. Kozanowski: I don't think there is fundamentally. There may be small discrepancies which we have not been too aware of, have suspected there might be troubles, but accurate check of gray-scale behavior over the full luminance range indicated that the things track pretty well from the standpoint of gamma. We do add additional gamma to the vidicon characteristics, 0.65 for the vidicon itself and an additional 0.7 on top of that as circuit gamma.

Mauro Zambuto (Transound Inc.): Did you experiment with different types of color film? If so, did you notice any consistent difference in the type or amount of masking necessary for each different type of color?

Dr. Kozanowski: You have a freedom of choice for the filters that go into the three vidicons. Once having selected the filters one can go from there into the electronic masking techniques. If you use narrow trimming filters you can get the appearance of very, very high saturation. But if you have unusually high saturation to begin with, then you have the problem of things being overdone. In the case of using narrower than idealized filters you are apt to run into the problem of what you are going to do with this enhanced appearance of the picture. In the case of an electronic masker it is very simple to control degree or turn it out altogether as the situation requires.

Charles E. Dean (Hazeltine Corp.): In any of these masking operations you have a condition where you take a linear combination, and you get what you want at the output but you also get all the noise. For example, you may want to get less signal output than two inputs would add up to, but you get the sum of the noise from these inputs. Have you encountered any limitation due to this kind of difficulty?

Dr. Kozanowski: To a certain extent that is strictly true. But if you start out with a very good signal-to-noise ratio you have lots of room in which to meander around. Ideally, if you set 300 to 1 without aperture correction depending on the input amplifier characteristics and with aperture correction 100 to 1, which you do not need in red and blue, the system is very tolerant of what you do masking wise.

Exposure Determination Methods for Color Printing: The Concept of Optimum Correction Level

By C. J. BARTLESON
and R. W. HUBOI

The major work in the field of printing exposure determination is reviewed, and a bibliography is included. A new concept in the use of integrated transmittance in automatically determining printing exposures for color materials is discussed. This method entails the use of an optimum correction level for any given negative or transparency population. This correction level is a compromise between the incompatible correction requirements of various segments of the population.

Although many of the methods for determining printing exposure were formulated relatively early in the history of photography, it has been only within recent years that many of the basic problems have been studied. There has often been much controversy regarding the relative adequacy of various criteria for determining exposures and many of the terms used have suffered from differing interpretations. While it is not the intention of the authors to present a definitive discussion of the subject, it does seem warranted to re-examine some of the basic considerations involved in the determination of printing exposures before proceeding to examine one of the newer approaches to the problem.

There are many sources of variation in the printing characteristics of color negatives or transparencies. Some of this variability is within the control of the photographer. The rest is introduced by conditions of manufacture, storage and processing which occur before and after he obtains and exposes the film stock. Regardless of the source of variability, a printing system that handles color materials should eliminate or minimize the resultant effects on the quality of color prints which it produces.

In order to produce color prints of salable quality, then, a color printer must provide compensation for color and density variations between individual negatives or scenes. This requires some means of varying both the level of printing exposure and its spectral quality. Adjustment of these exposure parameters is referred to as "exposure control." The level of exposure may be adjusted by varying either the printing time or printing intensity, or both. Printing intensity variations are used in motion-picture work for convenience. The spectral quality of the exposure may be adjusted by the use of color compensating filters to alter the quality of a "white light" source or by separately controlled red, green and blue light exposures.

The assignment of values to a particular set of exposure parameters for a given negative or scene is referred to as "exposure determination." The devices for exposure control may vary from one printing system to another, but the basic principles of exposure determination are common to all.

Many of these principles have long been established. Some are more recent modifications of methods for using long established criteria. All, however, are basically related in that they attempt to predict, either wholly or partially by objective methods, the most accurate or subjectively satisfying print. It seems appropriate, then, to review briefly the major contributions to the theory of printing exposure determination in order that any new concept might be placed in perspective with regard to the logical developments preceding it.

Review of Previous Methods

The determination of printing exposure originated in the early nineteenth century with the negative-positive concept of photography. Any system of arriving at an exposure sufficient to produce a print was entirely empirical and, because of the slow response of available materials, interest was more in the results of printing rather than in the theory of predicting optimum printing exposures.

The silver chloride paper with excess nitrate content required such prolonged exposure times at high light intensities that exposure could easily be determined by inspection during the printing process itself. Even with the advent of latent image development and improved chloride papers, exposure times were still excessively long. The introduction of silver bromide paper first indicated the possibility of automatic machines for production of photographic prints.

About 1880, silver bromide paper was adopted in England for producing enlarged photographic prints, and four years later, in the United States, the Eastman Dryplate and Film Company began producing the more sensitive paper on a large scale. Thus, large volume, automatic print production was made possible.[1]

The first photographic printing device which apparently satisfied contemporary demands was constructed by a Viennese engineer named Schlotterhoss in 1883.[2] Since silver bromide paper was not produced on a large scale in Germany until about 1894, this machine had to be used in conjunction with the slower chloride papers, thereby limiting the efficiency of the system.

In 1894 Arthur Schwarz founded Die Neue Photographische Gesellschaft in Berlin, which produced a number of semiautomatic printers and further extended their "rapid automatic" system by perfecting both developing and finishing machines.[3]

The exposure prediction methods of these printers, together with all the preceding attempts to determine printing exposures, seem to have been entirely empirical and the only means of adjusting for differences in negative characteristics was to make and remake prints until an acceptable exposure had been found for a given negative.

In 1902, however, Joseph Poliakoff patented a printing device with an accompanying method of *objective* exposure determination.[4] He used the total transmittance of a negative for exposure prediction. The light transmitted by a negative was deflected by a mirror onto a piece of actinic paper which, in turn, reflected light to a selenium cell. As the paper darkened, the cell current was reduced and at a preselected current value a solenoid closed the shutter which had been opened upon initiation of the exposure cycle. Although crude in form, this disclosure outlined the basic concepts upon which the majority of later, automatic printing systems have been based.

The Poliakoff patent was the first of a number of early patents that utilized information from the entire negative.[5] These subsequent systems were so arranged that, either by control of the intensity or adjustment of printing time, the exposure product at the print material surface remained constant. Although no reference was made to the relationship between monitor information and printing exposures selected, it is evident that a system of complete correction, based on

A contribution from the Color Technology Division, Eastman Kodak Co., Kodak Park, Rochester 4, N.Y.

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total integrated transmittance, was the first method used for determining exposures in automatic printing.

The almost universal use of this single criterion did not go completely unchallenged, however. Before long, workers began examining it in relation to other possible methods for predicting optimum printing exposures. For example, a study of physical functions of negatives as exposure indices was made by F. Twyman and is outlined in a patent issued to him in 1933.[6] From his investigation he decided that the most useful information was still the total transmittance of a negative and that the printing reaction could best be described by an equation previously used by Dobson, Griffith and Harrison[7]:

$$D_p = \gamma_p \cdot \log_{10} I \cdot t^{p'} - i \qquad (1)$$

where:

D_p = total $\log_{10}$ opacity of the developed print stock
γ_p = the slope of the straight portion of the D-log E curve of the print stock
I = total printing intensity
t = printing time
p' = Schwarzchild's constant
i = inertia constant.

Using this equation, it was considered possible to determine the printing conditions necessary for producing a desirable print density on a given print material. The printing time (t) could be adjusted to satisfy the exposure element of the equation ($I \cdot t$) as determined by the amount of light transmitted by the entire negative.

After a cursory examination in 1932[8] C. M. Tuttle made a rather extensive study of amateur pictorial negatives in 1937.[9] He suggested three physical measurements of a negative which might be used alone or in combination with each other. These were the "maximum density," "minimum density" and "total density" of a negative. The total density was actually the negative logarithm of the integrated transmittance of an entire negative image area.

Prints were made according to determinations based on each of these criteria. These prints were compared to prints which had been produced by the ideal exposure (as determined by the "average amateur choice") and a correlation curve between ideal log E and measured density was determined by the method of least squares. Tuttle found that "the slope of the log E/total D curve is unity within the error of determination, which signifies that the required exposure is inversely proportional to the total negative transmission." He also found that in exposure determination based on physical measures, the method using total density produced the best distribution of predicted exposures around the points of correct exposure.

Later that same year Tuttle further clarified his approach by showing the mathematical representation of the total D method.[10] Printing exposure was defined by him as the product of exposure time and source flux incident on the negative during printing. (This is contrary to the current notation of printing exposure as the product of the actual printing flux at the print material plane and the time of its incidence. However, it is evident from the equations listed by Tuttle that his exposure term is applicable to either source flux or exposure time.) He said, then, that if the total negative transmission is denoted by T_n or the logarithm of its reciprocal by D_n and the required "printing exposure" by E_p, the relationship could be written:

$$E_p = \frac{K}{T_n}, \qquad \text{or} \qquad (2)$$

$$\log_{10} E_p = D_n + \log_{10} K \qquad (3)$$

Thus, psychophysical and statistical support was given to the exposure determination criterion outlined by Poliakoff. However, it has long been known that the overall quality of prints produced by such a system can be improved by empirically adjusting the exposure determined on the basis of total transmittance in those cases where atypical scenes or negative characteristics are involved. The Eastman Kodak Company has both used and recommended such empirical adjustment methods, or "classification" systems, in conjunction with printers operating on the basis of this criterion for a number of years. In 1950 Varden and Krause[11] felt that the total density concept, or what might be more accurately referred to as the density value corresponding to the integrated transmittance of an entire negative (or transparency) image, was the most practical and useful information but that additional information regarding the relationship of the important subject area characteristics to the entire negative was needed. Both Varden[12] in 1946 and Rath[13] in 1948 have disclosed devices for calculating such classification factors based on the ratio of total transmittance to subject transmittance (or $D_{subject} - D_{total}$). It has also been found practical for skilled operators to estimate these factors with a high degree of accuracy.

In spite of the simplicity by which total integrated transmittance information may be obtained in automatic printing devices, this has not been the only criterion to be extensively examined as a means for determining printing exposures. Manual methods, especially, broke away from the exclusive use of total transmittance or density information. It is well known, for example, that motion-picture timing has been done for many years on an entirely empirical and subjective basis. Similarly, many of these other criteria resulting from various studies have found practical application, often in automatic or semiautomatic printing devices.

Probably the earliest thorough analysis of the problem was made in 1922 by E. Goldberg.[14] He felt that print highlights were the most subjectively important portion of the reproduction and, therefore, the maximum image density of a negative should be used in determining printing exposures. Similarly, Nidetzky[15] in 1943 suggested, in effect, that the maximum subject density of a negative should be used. He proposed that in determining camera exposure the lowest scene brightness should be used as the exposure index since, presumably, it should produce the lowest density on the image curve. However, he admitted that, at times, this should be weighted by the ratio of minimum to maximum brightness. Recently, Moon and Spencer[16] have proposed that every scene has a unique exposure requirement. This would imply that the exposure requirement for a given scene would exhibit some effect upon the choice of printing exposure.

H. R. Dammond in 1942 and A. Simmon in 1948–50 described a movable photoelectric probe to measure image brightness, at the printing plane, of any portion of a negative image.[17] Thus, direct measurement of printing flux for any area considered to be most subjectively important could be effected.

Morse[18] and Senger[19] in 1942 both suggested the use of a mid-tone negative density from a standard gray object included in the original scene as the basis for printing exposure determination.

In 1936, Szuboritis[20] disclosed a scanning system which was used to determine maximum negative density. Exposure was based on this measurement. Scanning information has more recently been used in a printing system developed by D. R. Craig.[21] In this device, a flying-spot scanning-raster is used for exposure by effecting pointwise printing flux normalization. Although complete, inverse feedback is maintained by the printer servo, image information is retained since relatively large spot sizes are used. Thus, effective reproduction gamma is reduced while retaining the informational content of the reproduction.

Tuttle, Cartwright and Eichler[22] in 1949 described a method of exposure determination based on the "background" density of a negative somewhat weighted by the subject density. This system allows complete correction for anomalous negatives. The method was specifically designed for printing "V-Mail" negatives; however, the inventors claim that it is not limited to this type of negative but may be used with pictorial negatives as well. A form of scanning was used in which the negatives, in the form of rolls, traveled across the monitor. The monitor was so situated that part of the subject (handwriting) as well as background image passed across the monitor beam. Since the background of these

negatives represented maximum density and subject density was equal to minimum density, it is evident that this was an exposure determination method based on maximum density and adjusted by a "contrast" factor. A similar proposal was made by Balsey[23] in 1935 to monitor "a portion" of a motion-picture sound record and adjust printing source intensity on this basis.

In 1942 Jones and Nelson[24] made a detailed study of approximately 200 amateur pictorial negatives. In all but five cases these negatives were properly exposed and developed. There were, then, essentially no exposure or development errors represented in their investigation. They utilized a psychophysical, statistical approach to the problem of evaluating the physical aspects of these negatives as criteria for determining printing conditions. In this investigation, Jones and Nelson determined the best printing exposure and paper contrast for each negative by making a series of prints, differing in exposure and contrast, and asking a number of observers to select the most pleasing print. The logarithm of the preferred printing exposure function for each negative was plotted against each of three respective density measures: (a) minimum density, (b) total density, (c) maximum density. A straight line, fitted to the plotted points by the method of least squares, was found to represent reasonably well, the optimum relation between each density measure and the logarithm of the preferred exposure. In each case the slope of that line was appreciably different from unity. It was noted, then, that the relation between correct printing exposure and each type of density measure was approximated best by an equation of the form, $\log E = b' + a \cdot D$, where a is the slope and b' depends on the speed of the print material and certain printer characteristics.

It was found that by averaging the data from all contrast grades, the minimum density equation had a correlation coefficient of 0.92, and a slope of 1.3. The best total density (corresponding to the integrated transmittance) equation had a correlation coefficient of 0.90 and a slope of 0.88. The use of maximum density gave a poorer result than either the minimum or the total density; the correlation coefficient was 0.82 and the slope of the best line was 0.74. From this it was concluded that the minimum density of a properly exposed and developed black-and-white negative is the best criterion for the determination of correct printing exposure. It was further concluded that for the sake of simplicity a unity slope could be used in the printing equation, particularly where prints may be developed by inspection.

In evaluating the preferred exposure data, Jones and Nelson found no systematic exposure trends as a result of classifying the scenes into "distant," "semi-distant" and "close" categories or into "portrait" and "non-portrait" categories. From this they concluded that "the criterion of correct printing exposure is not a function of scene type (as defined by our system of classification), or, if it is related in some way to scene type, the present study, either because of experimental errors or lack of sufficient number of cases has failed to reveal the dependency." It should be noted that Jones and Nelson were concerned with the printing of amateur pictorial negatives, a situation in which the reproduction requirements are different from those associated with motion-picture work. However, the reason for this conclusion probably lies in the method used to group the experimental negatives. Negatives were placed in groups that were homogeneous in one respect, but not necessarily homogeneous with regard to subject-to-entire-negative density relationship. Thus, in terms of primary interest areas, the groups may actually have been random and, therefore, it would not be expected that any effect of subject (or scene type) upon the exposure determination method would necessarily show systematic trends.

Methods for Color Printing

All of these methods have dealt with the determination of exposure sufficient to produce a desired density level in the print material. In the case of color printing it would be necessary to include a separate step of color-balance determination in order to produce the desired color as well as density level. The first methods of color-balance determination were empirical. The art of empirical color adjustment reached a relatively high degree of efficiency, and in some cases rather elaborate equipment has been utilized to facilitate such determinations.[25] Manual densitometry has been used to a large extent, but information in the field of automatic or semiautomatic color exposure determination is meager.

The simultaneous determination of both spectral quality and level of exposure was first used in the field of graphic arts. In 1937 H. E. J. Neugebauer[26] derived equations for correcting color and density in the production of halftone images. In 1948 Hardy[27] extended the Neugebauer equations to four-color halftone printing and proposed to scan a negative, simultaneously solving the three equations for each area of the scanning spot and exposing the separation negatives. By doing so, it was possible to determine the desired exposure for color and density together with any desirable exposure adjustments for small areas of the negative, thereby providing effective masking of the negative to correct for deficiencies of the dyes or pigments used in the reproduction.

There have been a number of proposals for this type of exposure determination in the field of photomechanical reproduction.[28] F. Preucil and others have listed and described the historically important and contemporary methods of facsimile reproduction.[29]

There have also been a number of disclosures relating to color exposure determination in the field of general color photography. In 1942, for example, Senger[30] described a densitometry device that could be used for determining equivalent neutral densities or, presumably, to effect density comparisons. The red, green and blue information was transduced to a group of lines on the screen of a cathode-ray tube that could be compared to reference lines on the screen. In this way, it would be possible to determine the variation from ideal or normal density for each color. In 1951 Varden[31] disclosed a somewhat similar device in which a sensitometrically exposed area was measured by a photomultiplier tube. Between the monitor tube and the sample there was a revolving wheel containing red, green and blue sectors. The movement of this wheel was synchronized with the scanning field of a cathode-ray tube such that a neutral (or ideal) density produced an even horizontal trace. An increase or decrease in the density of any one primary color caused a peak or depression in the corresponding area of the screen. By inserting colored filters in the sampling beam it was possible to alter the signal until the entire scanning line was again horizontal. The filter values which caused the scan to appear level were used in subtractive printing to obtain proper color balance.

This device would be capable of indicating film variability due to processing or some improper storage effects. However, since the area to be measured was sensitometrically exposed in the processing laboratory, it would not necessarily be related to scene type or exposure defects such as improper spectral quality of the exposing illuminant.

R. M. Evans[32] has shown that it is possible to determine the color and level of exposure simultaneously by merely measuring the red, green and blue integrated transmittance of an entire negative. Thus, red exposure is a function of the red transmittance characteristics of the negative, green exposure depends only upon the total green transmittance, and so on for the blue. This system is based on the assumption that the negative records of most scenes will integrate to gray or some other hue near gray.

The integrated transmittance measure is biased toward the minimum density region of the record. The magnitude of this bias depends upon the nature of the negative and the scene recorded on it. The effect of improper exposure, variation in illuminant quality, improper storage and any processing variations on the minimum density region are assumed to be relatively unmodulated by the important subject matter which is generally

more highly evidenced in the higher density portions of the negative. Obviously, this is not always the case. However, it has been found to be true in a large number of instances.

The assumption states, then, that integrated transmittance should be most sensitive to negative variations caused by anomalous exposure and storage conditions. Therefore, normalization of integrated printing transmittance should essentially eliminate the major effects of these anomalous conditions.

Therefore, if the total integrated transmittance of any one color varies from normal or standard, an increase or decrease in the additive exposure for that color should be produced. In this way both the color and density variations from standard can be normalized during the printing operation. This method of exposure determination may be represented as:

$$F_i = 10^{k_i}/T_i, \quad \text{or} \quad (4)$$
$$\log_{10} F_i = k_i + D_i.$$

where:

F_i = printer source flux (although the same form would hold for exposure time in the case of a variable-time printer)
k_i = a constant associated with the printer balance
D_i = the density value corresponding to the total integrated transmittance (T_i), or, in other words, the negative logarithm of T_i
i = red, green or blue.

It may be seen from this function that the method provides linear correction for both color and density variations from normal integrated transmittances of various negatives.

A possible modification to this method was described in 1950 by L. W. Smith.[33] This proposal suggests modifying the degree of correction in order to accommodate transparencies that differ appreciably from average in both density and subject matter. The device described directs light from the variable-intensity printing source onto the monitor. The result of this diluting light is to reduce the effective monitor response to the negative transmittance. It should be noted, however, that as the negative's integrated transmittance is lowered, both source flux and diluting light intensity are raised. It may be seen, then, that the diluting light intensity becomes disproportionate to the integrated transmittance signal so that the end result is not a linear departure from full correction, but is nonlinear. Mathematically it is possible to derive the result of this diluting light action on the monitor signal:

$$(F_i)(T_i) + (b_i)(F_i) = 10^K, \quad (6)$$

from which it follows that:

$$\log_{10}F_i = K + D_i - (0.434)(2) \left[\left(\frac{b_i}{2T_i + b_i}\right) + \frac{1}{3}\left(\frac{b_i}{2T_i + b_i}\right)^3 \cdots\right] \quad (7)$$

where:

T_i = integrated transmittance of the entire negative
D_i = logarithm of the reciprocal of T_i
F_i = source flux
$(b_i)(F_i)$ = diluting light flux
10^K = a constant
i = red, green or blue.

Obviously as b, or the percent dilution, becomes larger the nonlinearity represented in Eq. 7 becomes more pronounced.

Automatic Printing

It seems apparent from the foregoing examination of various methods by which printing exposures have been determined that, although many of these methods were formulated relatively early in the history of photography, it has only been within recent years that many of the basic problems have been rigorously studied. Similarly, it is only recently that the problem of determining exposures for color prints has been considered to any appreciable degree. With the increasing use of color materials it is necessary that these efforts not only be continued but be intensified. Otherwise, the production of color prints, because of the many peculiarities of the medium, will present difficult problems to the processing laboratory.

For the past several years, new methods for automatic printing of color materials have been investigated in these laboratories. Most printing methods presently used are only semiautomatic in that printer operators must critically judge the transmittance characteristics of scenes recorded in negatives and modify the exposures produced by the printer servo system. The necessity of this human link has been a major obstacle to achieving a completely automatic printing system. While it may not be completely eliminated in some operations where very critical requirements are placed on the quality of outgoing prints, such as in the motion-picture laboratory, it is none the less conceivable that the burden of operator judgment may be lightened by new methods of printing. This would result in at least a more efficient overall printing system. In the case of some amateur color printing applications, for example, it seems feasible that complete automation could be achieved. This automation of the printing system would have many advantages including:

1. Increased productivity
2. More uniform print quality
3. Decreased printing labor costs
4. Reduction of skill requirements for printer operators
5. Simplification of the inspection methods.

Even in the event that complete automation could not be achieved in applications where very high quality standards must be met, the lessening of the operator or timer's burden in estimating corrections for off-balance prints would constitute a large gain in the efficiency of the printing system. It is obvious that a necessary requirement for a new exposure determination method that might permit automatic printing is that resultant overall, absolute print quality must at least equal that obtainable with semiautomatic printers.

Attempts to achieve complete automation of color printing systems have in large measure been unsuccessful in the past. Additional subjective evaluation has been found desirable in the majority of such cases in order to attain sufficiently high quality levels. This need for subjective evaluation has stemmed primarily from the nature of monitor information and the manner in which it has been used.

The remainder of the discussion will consider a new approach to automatic color printing which utilizes integrated transmittance as an exposure determination criterion. This measure has often been used for determining printing exposures, and as noted above, it has provided a simple means of controlling both the color and density of color prints. The ready acceptance of integrated transmittance methods in semiautomatic printing systems is undoubtedly due to the simplicity by which this measure is obtained in such devices. Application of these new principles does not necessitate the use of uncommon or unusually complex equipment.

The Correction Level Concept

It was noted earlier that the monitor analog of integrated transmittance information is almost always used to control exposures such that the total amount of light transmitted by a negative is normalized. In other words, any anomalous values of total or integrated printing exposure are fully corrected to some constant value. This concept is also the basis of the method proposed by R. M. Evans[32] for the simultaneous determination of both spectral quality and level of exposure by means of integrated transmittance. By that method the total or integrated amounts of red, green and blue printing exposure used in the printing of all negatives or transparencies are completely or nearly completely corrected to constant values.

There are many methods by which the spectral quality and level of the printing exposure may be varied in order to effect this correction. For example, in additive printing systems the spectral quality of the exposing illuminant may be varied by changing the ratio of red, green and blue intensities, either simultaneously or sequentially. Or, an equivalent effect may be achieved by maintaining constant intensities and changing the ratio of effective red, green and blue exposure times. Similarly, the

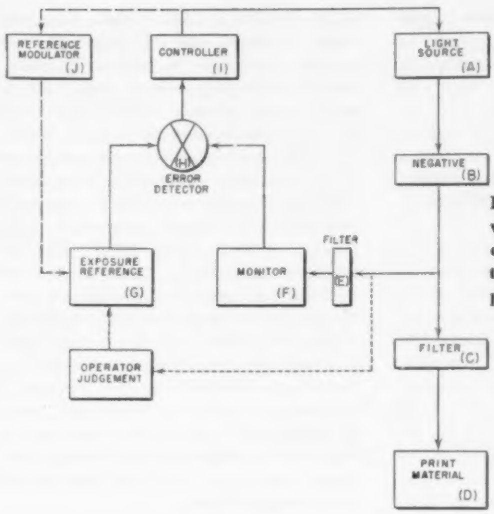

Fig. 1. Basic servo for a variable-intensity printing device using integrated transmittance as the exposure criterion.

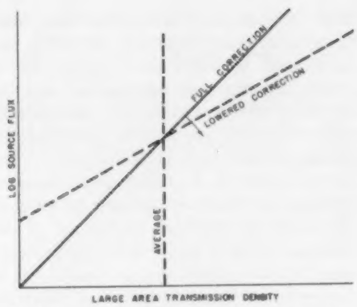

Fig. 2. A linear relationship between log source flux and LATD. Full correction is shown as a line with unity slope. Lowered correction systems will have relationships with slopes less than one. Since the average exposure corresponding to the average negative should remain constant, correction level changes are rotated about this average point.

spectral quality and level of exposure may be controlled subtractively by direct spectral modulation (as with color compensating filters) of one variable-intensity source. There are, of course, other combinations of these controls which may be used to effect the same results.

Rather than burden the discussion with details relating to any one such printing device we will consider a relatively simple printing system in only the most generally descriptive terms. We shall assume that the device under consideration modulates both spectral quality and level of exposure by varying the ratio of three sequential color exposures.

A schematic diagram showing the basic elements for exposure determination and control in such a printing system is shown in Fig. 1. These basic components are required to adjust each individual color exposure for any negative:

A. Light source — Provides actinic energy for producing the exposures.
B. Negative.
C. Printing filter — Red, green or blue.
D. Print material.
E. Monitor filter — Red, green or blue.
F. Monitor receptor — Through its filter, evaluates the energy transmitted by the total negative, preferably in a manner linearly proportional to the total response of the corresponding color-sensitive layer of the print material.
G. Exposure reference — Provides a reference signal which is the analog of the desired printing exposure for a given color.
H. Error detector — Compares monitor and reference signals and generates an error or difference signal.
I. Exposure controller — Adjusts the intensity of the light source in accordance with the error signal.
J. Reference modulater — A feedback device which varies the exposure reference as a function of the controller action.

The closed loop depicted by the solid lines in Fig. 1 is generally common to either manual, semiautomatic or automatic systems. In manual printing applications the human operator may constitute the left side of that loop. He may provide a total or partial visual evaluation of the negative, an intuitive type of exposure reference, and/or he may manually control the printing exposure itself.

Although this type of operation has found widespread use in the printing of black-and-white motion pictures, it is of only limited effectiveness in color printing. This is especially true for the case of color negatives where color balance variations are difficult to evaluate in complementary terms. This discussion will therefore be limited to completely automatic or semiautomatic systems.

Semiautomatic systems differ from automatic systems in that the printer operator may modify the exposure reference signal in accordance with some classification system. This portion of semiautomatic systems is indicated by the dotted lines in Fig. 1.

Operation of the variable-intensity system of Fig. 1 may be described by a simple linear equation for each color exposure in which the logarithm of the source flux is proportional to Large Area Transmission Density (LATD). LATD is a term which is used here to refer to the density value corresponding to the total integrated transmittance of a negative or transparency. This, then, is *not* the integrated density of the negative, but is the logarithm of the reciprocal of the integrated transmittance. The term is used only for its convenience in expressing the logarithmic relationship of source flux and negative transmittance. The printing equation may be written as:

$$\log_{10} F_i = K_i + c_i D_i \qquad (8)$$

where:

F_i = source flux
K_i = a constant representing the aim point of the system
D_i = LATD
c_i = a coefficient
i = red, green or blue.

The coefficient c_i represents the rate of correction for LATD variation among negatives. A unity coefficient is set into the printer for full correction if the spectral response of the printer monitor is identical to that of the print material. However, when this coefficient has a value less than unity, then less than full correction is applied in the printing system. These conditions are illustrated graphically in Fig. 2.

Departure from full correction may be brought about in a printer either optically or electrically, inadvertently or by design. If the spectral responses of the red, green and blue monitors, through their respective filters, do not match the corresponding responses of the combination of paper and printing filter, positive or negative exposure shift may result. That is, the effective value of the coefficient, c_i, will be either greater or less than unity. Shifts produced by monitor mismatch may be partially compensated by an electrical circuit providing feedback between the printing lamp and the exposure reference. This is represented by the reference modulator loop, shown as dashed lines in Fig. 1. This circuit should be adjustable and reversible in order to provide variable amounts of positive or negative shift as required by the system. In addition, this circuit provides a convenient means for varying the correction level of the printing system.

It has been noted that the full correction concept is based on the assumption that most scenes are generally character-

ized by constant integrated hue and brightness. Any difference between the integrated transmittance values for a given negative and the normal value is assumed to be due to the undesirable effects of such anomalous conditions as over-exposure and under-exposure, improper illuminant quality and improper storage, in addition to any processing variations. If, however, the nature of the original scene is such that a preponderance of any one color or brightness is represented, then the printing exposure determined by such a system will be in error. The failure of certain scenes or subject matter to conform to normal integration values is referred to as "subject failure."

Negatives may exhibit both color and density subject failure. In the latter case, the overall density of a negative departs from normal owing to the nature of the scene rather than to camera exposure level. One example of such a "subject anomaly" would be the negative record of a white cat photographed against a snow bank. A full correction printer would produce too dark a print from such a negative. In like manner, if the density of the major portion of a negative is considerably different from the density of the important subject area, the resultant print will not be optimum. These situations have been dealt with in part through the use of various systems of classification previously mentioned. This operation must be carried out prior to printing. Negatives are visually inspected by printer operators, and an estimate is made of the necessary exposure adjustment required to produce optimum print density. The demands and limitations of such a system are obvious.

If the nature of the original scene or subject is such that one color predominates, then color subject failure will occur. A classic example is the negative record of a person in a red coat standing in front of a red barn. The low total red transmittance of the negative will call for an increased red exposure, resulting in the production of too much cyan dye in the print.

Attempts to prevent color subject failure by means of "color classification" are not too successful with color negatives. This is especially true of color negatives containing colored masks produced from the dye couplers in the film emulsion. Relatively minor variations in the overall color of the image are not easily detected by the eye in the presence of these masks. Hence, the color subject errors made by such full correction systems constitute a major source of error and print waste.

It is possible to divide a negative (or transparency) population into three general categories for the purposes of discussion: (a) normal negatives, (b) negatives involving normal scenes but improperly exposed or showing the effects of faulty storage and (c) subject failure negatives. Full correction is required to produce optimum prints from improperly exposed negatives. However, negatives exhibiting only subject failure (and no exposure anomalies) require no correction for the production of optimum prints. Furthermore, the effect of correction in such negatives is deleterious to resultant print quality.

Since properly exposed negatives which do not exhibit subject failure integrate at or near the norm, very little or no correction is required. For this reason normal negatives are not greatly affected by correction level. The problem resolves itself, then, to the formulation of a method for determining printing exposures which will most effectively comply with the incompatible correction requirements of negatives involving improper storage or exposure and those exhibiting subject failure.

An obvious approach would be to effect a compromise between full correction and no correction. This would mean that the value of the coefficient c_i in Eq. 8 would be less than unity.

As the correction level is lowered, the printing exposures determined for subject failure negatives approach optimum. In Fig. 3 it may be seen that the effects of both density and color subject failure are minimized in those prints produced at the lower levels of correction. As the correction level increases, the subject errors become increasingly more objectionable. On the other hand, it may it may be seen in Fig. 4 that for the case of improperly exposed negatives the prints produced by high correction appear more nearly optimum than those which received less correction.

The prints in Figs. 3 and 4 represent extreme subject failure and improper exposure. In practice the negatives from any population include examples incorporating many degrees of these anomalous conditions. In addition, a number of combinations may occur in an individual negative.

It is desirable to achieve a correction level such that an optimum compromise is effected between print quality losses due to undesirable anomalies and those resulting from subject failure. Proper choice would result in optimum *overall* print quality for the entire population. Furthermore, the need for classification would be decreased as the subject errors are minimized.

Practical Application

A statistical method has been employed in order to determine these correction levels for amateur roll-film color negative populations. Samples of 1,000 negatives were chosen during each month of an entire year. These samples were chosen in a manner which would produce a typical cross section of the entire negative population.

The LATD values of these negatives were measured, and initial printing exposures determined by manual computation. These exposures were then made on a manual printer which permitted precise, quantitative control of source flux. The resultant prints were evaluated by a group of specially trained inspectors whose ability was tested by a number of methods which indicated that their print judgments were valid. The inspectors estimated any correction in flux necessary to produce the optimum print from a given negative. Corrected flux values, together with the Large Area Transmission Densities of the negatives, were then analyzed by the method of least squares, as in the Jones and Nelson investigation,[24] and the linear equation of "best fit" was determined for each color. These regression equations are of the same form as Eq. 8.

It was found that the optimum coefficients of these linear equations varied within the range of 0.70 to 0.90 depending on the season of the year. This indicates that the ratio of undesirable anomalies to subject failure is not constant but changes somewhat from one season to another. In general, the highest coefficients corresponded to the midwinter season while the lowest values occurred during midsummer. Seasonal variations were also noted in the corresponding printer aim points, represented by the constant K_i of Eq. 8.

The correction levels, expressed as the value of c_i, are, of course, a function of the type of negative population. In this case an amateur roll-film color negative population with the high incidence of improper exposure usually associated with such negatives was analyzed. It is of interest that in the experiments of Jones and Nelson[24] with pictorial black-and-white negatives the average coefficient of 0.88 which was determined for total density lies within the range of 0.70 to 0.90 for c_i in these experiments with color negatives. However, it is not necessarily to be expected that other color negative or transparency populations would require the same level of correction as was indicated by this study. There are, none the less, a number of fundamental implications which may be drawn from the results of the experiment.

Conclusions

The best correction level for any integrated transmittance printing system is a function of the characteristics of the negative or transparency population. The actual optimum level of correction is dependent upon the proportional occurrence of desirable and undesirable anomalies. Color and density subject failure are anomalous conditions in that the negatives or transparencies fail to satisfy the basic assumption of integrated transmittance printing. In other words,

the true camera exposure conditions are not adequately represented by the integrated transmittance of the negative in these cases. The monitor information is misleading in that it calls for correction where none is needed. These so-called anomalies result from scene attributes which must be retained in order to satisfy the requirements of adequate reproduction. On the other hand, the undesirable effects of improper exposure, storage, poor processing, etc., should be eliminated. The relative occurrence of these factors is obviously related to the type of color material being printed.

It is apparent, then, that the range of optimum correction level will not be the same for printing all types of negative or transparency materials. For example, the proportion of exposure errors might be expected to be higher in an amateur color negative population than in a professional population such as encountered in portraiture or in motion-picture work. It would be expected that the optimum correction levels for such populations would be lower than those encountered in an amateur color negative printing system.

An optimum correction level may be achieved with any population, then. The advantages attained by such a compromise are twofold. The *overall* quality of the system may be improved with respect to absolute level and consistency. In addition, operator skill requirements may be reduced. The magnitude of quality improvement as well as reduction in necessary operator skill is dependent upon the quality requirements of the system.

Thus, the use of the oldest criterion for automatic print production, after this modification to the concept of its use, may in some applications be capable of permitting completely automatic printing with a reduction of appreciable quality losses historically associated with such systems. The higher overall quality obtainable with integrated transmittance printing methods operated at an *optimum* correction level makes it a valuable tool in the production of color prints. Whether the system is used to produce more accurate initial prints or to provide release prints, it lessens the burden of decision and estimation which weighs so heavily on the color timer or printer operator. It provides an expedient and efficient method of producing salable or higher quality prints where empirical exposure prediction is often a long, laborious and expensive proposition. It eliminates many of the printing exposure errors introduced by the classical full correction printing systems. The use of optimum correction levels does, in fact, minimize printing errors and allow the integrated transmittance printing system to work at the highest overall quality level which it is objectively capable of attaining.

References

1. (a) J. M. Eder, *History of Photography* (trans. by E. Epstean), New York, Columbia University Press, 1945, Ch. LXI.
(b) C. B. Neblette, *Photography Principles and Practice*, 4th ed., New York, D. Van Nostrand Co., 1942, Ch. 1.
2. (a) Ger. Pat. 26,620, April 15, 1883 (Schlotterhoss).
(b) Photographische Korrespondenz, 1883, p. 332; 1884, p. 330.
3. F. Wentzel, "Geshichteliche Entwicklung der Bromsilber und Gaslichtpapier fabrikation," in J. M. Eder, *Handbuch der Photographie*, Band III, 1 teil, Halle, W. Knapp, 1930.
4. U.S. Pat. 700,083, May 13, 1902 (Poliakoff).
5. (a) U.S. Pat. 947,490, Jan. 15, 1910 (Gwozdz).
(b) Ger. Pat. 299,278, July 7, 1917 (Dix).
(c) U.S. Pat. 1,312,289, Aug. 5, 1919 (Wenderhold).
(d) Ger. Pat. 313,770, July 19, 1919 (Machts).
(e) Austrian Pat. 83,912, May 10, 1921 (Maurich).
(f) Ger. Pat. 377,251, June 15, 1923 (Traut).
(g) Ger. Pat. 392,218, Mar. 18, 1924 (Koch).
(h) Fr. Pat. 673,698, Oct. 8, 1929 (Societe Independente de Telegraphie Sans Fil.).
(i) U.S. Pat. 1,759,630, May 20, 1930 (Renaldy).
(j) Br. Pat. 339,781, Dec. 18, 1930 (Westinghouse Lamp Co.).
(k) Fr. Pat. 681,692, Feb. 3, 1930 (Raab).
(l) U.S. Pat. 1,836,607, Dec. 15, 1931 (Malcom).
(m) U.S. Pat. 1,813,635, July 7, 1931 (Meyers, *et al.*).
(n) U.S. Pat. 1,798,203, March 31, 1931 (Hill).
(o) U.S. Pat. 1,864,442, June 21, 1932 (Kinsey).
(p) U.S. Pat. 1,929,105, Oct. 3, 1933 (Sperbeck).
(q) U.S. Pat. 1,930,137, Oct. 10, 1933 (Twyman).
(r) U.S. Pat. 1,934,484, Nov. 7, 1933 (Cammilli).
(s) U.S. Pat. 1,908,610, May 9, 1933 Tuttle, *et al.*).
(t) U.S. Pat. 1,925,547, Sept. 5, 1933 (Tuttle, *et al.*).
6. U.S. Pat. 1,939,243, Dec. 12, 1933 (Twyman).
7. G. M. B. Dobson, I. O. Griffith and D. N. Harrison, *Photographic Photometry*, Oxford, Clarendon Press, 1926, p. 36.
8. C. M. Tuttle, "On the assignment of printing exposure by measurement of negative characteristics," *Jour. SMPE, 18:* 172–188, Feb. 1932.
9. C. M. Tuttle, "Photoelectric photometry in the printing of amateur negatives," *J. Franklin Inst. 224:* 315–337, 1937.
10. C. M. Tuttle, "Devices for photoelectric control of exposure in photographic printing," *ibid.*, pp. 615–631.
11. L. E. Varden and P. Krause, "Printing exposure determination by photoelectric methods," *Am. Ann. Phot., 64:* 1950.
12. (a) L. E. Varden and J. Robins, "Photoelectric controls for color printing," *Electronics, 19:* 110–115, 1946.
(b) U.S. Pat. 2,501,365, Mar. 21, 1950 (Varden).
13. U.S. Pat. 2,444,675, July 6, 1948 (Rath).
14. E. Goldberg, *Der Aufbau des photographischen Bildes*, Halle, W. Knapp, 1922.
15. G. Nidetzky, "Electrische Belichtungsmesser," *Handbuch der Photographie*, Erganzungswerk I, Vienna, Springer, 1943.
16. P. Moon and D. Spencer, "On photographic exposure and exposure meters," *Jour. SMPTE, 63:* 233–237, 1954.
17. (a) U.S. Pat. 2,293,425, Aug. 18, 1942 (Dammond).
(b) U.S. Pat. 2,438,303, Mar. 23, 1948 (Simmon).
(c) U.S. Pat. 2,518,947, Aug. 15, 1950 (Simmon).
(d) U.S. Pat. 2,518,948, Aug. 15, 1950 (Simmon).
18. U.S. Pat. 2,269,161, Jan. 6, 1942 (Morse).
19. N. Senger, "Fortschritte auf dem Gebiete des Agfacolor-Verfahrens," *Film und Farbe*, Berlin, Max Hesses Verlag, 1943. (Proc. Conference "Film und Farbe," Dresden, Oct. 1–3, 1942).
20. Ger. Pat. 626,052, Feb. 19, 1936 (Szuboritis).
21. D. R. Craig, "The LogEtron: A fully automatic servo-controlled scanning light source for printing," *Phot. Eng., 5:* No. 4, 1954.
22. U.S. Pat. 2,464,162, Mar. 8, 1949 (Tuttle, *et al.*).
23. U.S. Pat. 1,999,556, Apr. 30, 1935 (Balsey).
24. (a) L. A. Jones and C. N. Nelson, "Control of photographic printing by measured characteristics of the negatives," *J. Opt. Soc. Amer., 32:* 558–619, 1942.
(b) L. A. Jones and C. N. Nelson, "Control of photographic printing: improvement in terminology and further analysis of results," *J. Opt. Soc. Amer., 38:* 897–920, 1948.
25. (a) A. Schilling, "Zum Agfacolor-Kopierprozess," *Film und Farbe*, Berlin, Max Hesses Verlag, 1943.
(b) R. H. Alder, "Control of Color," *Min. Camera World, 2:* 441–442, 446, 1951.
(c) Br. Pat. 721,547, filed Dec. 27, 1951 (DeBrie).
(d) F. P. Herrnfeld, "Printing equipment for Ansco color film," *Jour. SMPTE, 54:* 454–463, April 1950.
(e) F. P. Herrnfeld, "A system for automatic additive printing and scene testing," *Jour. SMPTE, 65:* 256–259, May 1955.
26. H. E. J. Neugebauer, *Zeit. Tech. Phys., 36:* 22–89, 1937.
27. (a) U.S. Pat. 2,434,561, Jan. 13, 1948 (Hardy).
(b) U.S. Pat. 2,185,139, Dec. 29, 1939 (Wurzburg).
(c) A. C. Hardy and F. L. Wurzburg, "A photoelectric method of preparing printing plates," *J. Opt. Soc. Amer., 38:* 295–300, 1948.
28. (a) U.S. Pat. 1,814,987, July 14, 1931 (Weaver).
(b) U.S. Pat. 1,709,926, Apr. 23, 1929 (Weaver).
(c) U.S. Pat. 2,415,051, Jan. 28, 1947 (Thompson).
(d) U.S. Pat. 2,309,048, Jan. 19, 1943 (Curry).
29. (a) F. Preucil, "Electronic scanners for color correction," *Natl. Lithog., 57:* 40–41, 87, 89, June 1950; *57:* 28–29, Aug. 1950; *57:* 34–35, 90, 91, Sept. 1950; *57:* 50–51, 118, Oct. 1950.
(b) J. R. Gunther, "Color correction by electronics," *Amer. Photo Engraver, 41:* 1257–1261, 1949.
(c) H. F. Pulitzer, "Colour Reproduction," *Funct. Phot., 1:* 26–28, July 1950.
30. See Ref. 19.
31. (a) U.S. Pat. 2,544,196, Mar. 6, 1951 (Varden).
(b) L. E. Varden, "Semiautomatic color analyzer," *Jour. SMPTE, 56:* 197, Feb. 1951.
32. U.S. Pat. 2,571,697, Oct. 16, 1951 (Evans).
33. U.S. Pat. 2,529,975, Nov. 14, 1950 (Smith).

BIBLIOGRAPHY (According to Subject)

I. History and Background of Automatic Printing and Printing Exposure Determination

1. J. M. Blair, *Practical and Theoretical Photography*, New York, Pitman, 1939.
2. A. Brothers, *Photography; Its History, Processes, Apparatus and Materials, Comprising Working Details of All the More Important Methods*, London, Charles Griffin & Co., 1899.
3. L. P. Clerc, *Photography—Theory and Practice*, London, Pitman & Sons, Ltd., 1930.

4. G. M. B. Dobson, I. O. Griffith and D. N. Harrison, *Photographic Photometry*, Oxford, Clarendon Press, 1926.
5. J. M. Eder, *Systeme de sensitometrie des plaques photographiques*, Paris, E. Belin, 1903.
6. J. M. Eder, *Ausfuhrliches Handbuch der Photographie:* Band I, 1 teil, *Geschichte der Photochemie und Photographie*, Halle, W. Knapp, 1905. (Also: *History of Photography*, trans. by E. Epstean, New York, Columbia University Press, 1945).
7. *Ibid.*, Band II, 1 teil, *Die Grundlagen der photographischen Negativerfahren*, H. Luppo-Cramer.
8. *Ibid.*, Band III, 1 teil, *Fabrikation der photographischen Platten, Filme und Papiere*, F. Wentzel.
9. *Ibid.*, Band III, 2 teil, *Verarbeitung der photographischen Platten, Filme und Papiere*, J. M. Eder and H. Luppo-Cramer.
10. *Ibid.*, Band III, 4 teil, *Die Sensitometrie, photographische Photometrie und Spektrographie*, J. M. Eder.
11. W. B. Ferguson (ed.), *A Memorial Volume Containing an Account of the Photographic Researches of Ferdinand Hurter and Vero C. Driffield*, London, Royal Photographic Society, 1920.
12. E. Goldberg, *Der Aufbau des photographischen Bildes*, Halle, W. Knapp, 1922.
13. W. J. Harrison, *History of Photography*, New York, Scovill Mfg. Co., 1887.
14. K. Henney and B. Dudley, *Handbook of Photography*, New York, McGraw-Hill, 1939, and London, Whittlesey House, 1939.
15. R. Hunt, *Researches on Light*, London, Longman, 1844.
16. F. Hurter and V. C. Driffield, "Photochemical investigations and a new method of determination of the sensitiveness of photographic plates," *J. Soc. Chem. Ind.* (London), *9:* 455–469, 1890.
17. F. Hurter and V. C. Driffield, Br. Pat. 5,545; 1888.
18. L. A. Jones, *Photographic Sensitometry*, Rochester, Eastman Kodak Co., 1931.
19. R. Lecuyer, *Histoire de la Photographie*, Paris, Bechet & Co., 1945.
20. G. Le Gray, *Traite pratique de photographie sur papier et sur verre*, Paris, Lerebours, 1850.
21. H. Luppo-Cramer, *Photographische Probleme*, Halle, W. Knapp, 1907.
22. J. E. Mack and M. J. Martin, *The Photographic Process*, New York, McGraw-Hill, 1939.
23. C. E. K. Mees, *The Theory of the Photographic Process*, New York, Macmillan Co., 1942.
24. C. B. Neblette, *Photography Principles and Practice*, New York, D. Van Nostrand Co., 1927.
25. Photographische Korrespondenz, 1883, p. 332, and 1884, p. 330.
26. Shepperly, *A History of Photography*, London, Arthur Press, 1929.
27. C. Schiendl, *Geschichte der Photographie*, Leipzig, A. Hartleben, 1891.
28. D. A. Spencer (Editor in Chief), *Progress in Photography, 1940–1950*, London, Focal Press, 1950. (Also: *Progress in Photography 1951–1954*, London, Focal Press, 1955).
29. W. H. F. Talbot, *The Process of Calotype Photogenic Drawing*, London, J. L. Cox & Sons, 1841.
30. W. H. F. Talbot, *The Pencil of Nature*, London, Longman, Brown, 1844.
31. G. Tissandier, *A History and Handbook of Photography* (trans. by J. Thomson) London, 1876. (2nd. ed. with appendix by W. H. F. Talbot, London, 1878).
32. C. M. Tuttle, Devices for the Control of Exposure in Photographic Printing, *J. Franklin Inst., 224:* 615–631, 1937.
33. C. M. Tuttle, "On the assignment of printing exposure by measurement of negative characteristics," *Jour. SMPE, 18:* 172–188, 1932.
34. L. E. Varden and P. Krause, "Printing exposure determination by photoelectric methods," *Am. Ann. Phot., 64:* 1950.
35. J. W. T. Walsh, *Photometry*, London, Constable & Co., 1926.
36. J. Werge, *The Evolution of Photography*, London, Piper & Carter, 1890.

II. Analysis of Exposure Determination Methods

1. E. Goldberg, *Der Aufbau des photographischen Bildes*, Halle, W. Knapp, 1922.
2. L. A. Jones and C. N. Nelson, "Control of photographic printing by measured characteristics of negatives," *J. Opt. Soc. Amer., 32:* 558–619, 1942.
3. L. A. Jones and C. N. Nelson, "Control of photographic printing; improvement in terminology and further analysis of results," *J. Opt. Soc. Amer., 38:* No. 11, 1948.
4. G. Nidetzky, Electrische Belichtungsmesser. *Handbuch der Photographie, Erganzungswerk*, Vienna, Springer, 1943.
5. P. Moon and D. E. Spencer, "On photographic exposure and exposure meters, *Jour. SMPTE, 63:* 233–237, Dec. 1954.
6. C. M. Tuttle, "Photoelectric photometry in the printing of amateur negatives," *J. Franklin Inst., 224:* 315–337, 1937.
7. C. M. Tuttle, "Devices for the control of exposure in photographic printing," *ibid.*, 615–631.
8. F. Twyman, U.S. Pat. 1,939,243, Dec. 12, 1933.
9. L. E. Varden and P. Krause, "Printing exposure determination by photoelectric methods," *Am. Ann. Phot., 64*, 1950.

III. Manual Systems of Exposure Determination

1. A. W. Anthony, E. P. Oxnard and B. Oxnard, U.S. Pat. 2,090,825, Aug. 24, 1937.
2. J. M. Bing, U.S. Pats. 2,149,250, Mar. 7, 1939; and 2,201,606 May 21, 1940.
3. H. R. Dammond, U.S. Pat. 2,293,425, Aug. 18, 1942.
4. B. A. Dudley, "Precision exposures with a light integrating exposure control unit," *Photo Tech., 3:* Dec. 1941.
5. Eastman Kodak Company, *Kodak Color Densitometer*, Nov. 1953.
6. Eastman Kodak Company, *Kodak Color Films*, 1950.
7. A. B. Fuller, U.S. Pat. 2,000,589, May 7, 1935.
8. W. G. Houskeeper, "A system of projection print exposure," *Photo Tech., 1:* July 1939.
9. J. L. Michaelson, "Totalux—An integrating exposure meter," *Photo Tech., 2:* Feb. 1940.
10. K. Rath, U.S. Pat. 2,444,675, July 6, 1948.
11. H. E. Seemann and G. M. Corney, "Estimating radiographic exposures for multithickness specimens," *ASTM Bull.*, pp. 31–36, 1943. (Also: Amer. Soc. for Testing Materials Tentative Recommended Practice for Radiographic Testing, ASTM Designation E94-52T, 1952).
12. A. Simmon, U.S. Pats. 2,438,303, Mar. 23, 1948; 2,518,947, Aug. 15, 1950; 2,518,948, Aug. 15, 1950; 2,443,058, June 8, 1948; 2,480,424, Aug. 30, 1949.
13. A. Simmon and L. L. Weisglass, U.S. Pats. 2,430,253, Nov. 4, 1947; 2,462,340, Feb. 22, 1949; 2,480,422, Aug. 30, 1949.
14. L. E. Varden, U.S. Pat. 2,501,365, Mar. 21, 1950.
15. L. E. Varden and J. Robins, "Photoelectric controls for color printing," *Electronics, 19:* No. 6, 1946.
16. L. E. Varden and P. Krause, "Printing exposure determination by photoelectric methods," *Am. Ann. Phot., 64*, 1950.
17. L. L. Weisglass, U.S. Pat. 2,450,319, Sept. 28, 1948.

IV. Printing Exposure Determination Methods Based on Large Area Reflection Densitometry

1. W. D. Fleming, U.S. Pat. 2,472,815, June 14, 1949.
2. B. A. Kinsey, U.S. Pat. 1,864,442, June 21, 1932.

V. Printing Exposure Determination Methods Based on Large Area Transmission Densitometry

1. C. W. Adams, U.S. Pat. 2,254,878, Sept. 2, 1941.
2. P. C. Cofield, U.S. Pat. 2,633,784, Apr. 7, 1953.
3. Bucky and Einstein, U.S. Pat. 2,058,562, Oct. 27, 1936.
4. B. Burnham and E. Hoag, U.S. Pat. 2,353,-218, July 11, 1944.
5. Carter, U.S. Pat. 1,946,612, Feb. 13, 1934.
6. Cammilli, U.S. Pat. 1,934,484, Nov. 7, 1933.
7. A. G. Denis, U.S. Pats. 1,973,469, Sept. 11, 1934; 1,973,470, Sept. 11, 1934.
8. Dix, Ger. Pat. 299,278, July 7, 1917.
9. J. Eggert and H. F. Nisson, U.S. Pat. 2,101,932, Dec. 14, 1937.
10. R. M. Evans, U.S. Pat. 2,571,697, Oct. 16, 1951.
11. V. J. Forgett, U.S. Pat. 2,557,182, June 19, 1951.
12. Gwozdz, U.S. Pat. 947,490, Jan. 15, 1910.
13. B. I. Hill, U.S. Pat. 1,798,203, Mar. 31, 1931.
14. R. S. Hopkins, U.S. Pat. 1,946,621, Feb. 13, 1934.
15. Koch, Ger. Pat. 392,218, Mar. 18, 1924.
16. W. L. Linde, U.S. Pat. 2,463,985, Mar. 8, 1949.
17. Machts, Ger. Pat. 313,770, July 19, 1919.
18. Malcolm, U.S. Pat. 1,836,607, Dec. 15, 1931.
19. Maurich, Austrian Pat. 83,912, May 10, 1921.
20. J. W. McFarlane, U.S. Pat. 1,966,303, July 10, 1934.
21. Meyers and Wilkinson, U.S. Pat. 1,813,635, July 7, 1931.
22. Mihalyi, U.S. Pat. 2,058,483, Oct. 27, 1936.
23. J. Poliakoff, U.S. Pat. 700,083, May 13, 1902.
24. Raab, Fr. Pat. 681,692, Feb. 3, 1930.
25. J. Rabinowitz, U.S. Pat. 2,469,076, May 3, 1949.
26. Renaldy, U.S. Pat. 1,759,630, May 20, 1930.
27. Riszdorfer, U.S. Pats. 2,032,633, Mar. 3, 1936; 2,024,661, Dec. 7, 1935.
28. L. W. Smith, U.S. Pat. 2,529,975, Nov. 14, 1950.
29. Societe Independente de Telegraphie Sans Fil., Fr. Pat. 673,698, Oct. 8, 1929.
30. Sperbeck, U.S. Pat. 1,929,105, Oct. 3, 1933.
31. Tonnes, U.S. Pat. 2,051,061, Aug. 18, 1936.
32. Traut, Ger. Pat. 337,251, June 15, 1923.
33. C. M. Tuttle and L. A. Jones, U.S. Pat. 1,908,610, May 9, 1933.
34. C. M. Tuttle and F. E. Tuttle, U.S. Pat. 1,925,547, Sept. 5, 1933.
35. C. M. Tuttle, McFarlane and White, U.S. Pat. 1,954,338, Apr. 10, 1934.
36. C. M. Tuttle and D'A. A. Young, Jr., U.S. Pat. 1,987,036, Jan. 8, 1935.
37. C. M. Tuttle and F. M. Brown, U.S. Pats. 2,521,954, Sept. 12, 1950; 2,566,264, Aug. 28, 1951.
38. C. M. Tuttle, U.S. Pat. 2,058,531, Oct. 27, 1936.
39. Twyman, U.S. Pat. 1,930,137, Oct. 10, 1933.
40. L. E. Varden, U.S. Pat. 2,501,365, Mar. 21, 1950.
41. Wenderhold, U.S. Pat. 1,312,289, Aug. 5, 1919.
42. Westinghouse Lamp Company, Br. Pat. 339,781, Dec. 18, 1930.
43. F. C. Williams and F. M. Brown, U.S. Pat. 2,500,049, Mar. 7, 1950.
44. F. C. Williams, U.S. Pat. 2,566,277, Aug. 28, 1951.
45. D. A. Whitson, U.S. Pat. 1,925,355, Sept. 5, 1933.

VI. Exposure Determination Methods Based on Maximum Density

1. E. Goldberg, *Der Aufbau des photographischen Bildes*, Halle, W. Knapp, 1922.
2. G. Nidetzky, Electrische Belichtungsmesser, *Handbuch der Photographie, Erganzungswerk*, Vienna, Springer, 1943.
3. Szuboritis, Ger. Pat. 626,052, Feb. 19, 1936.

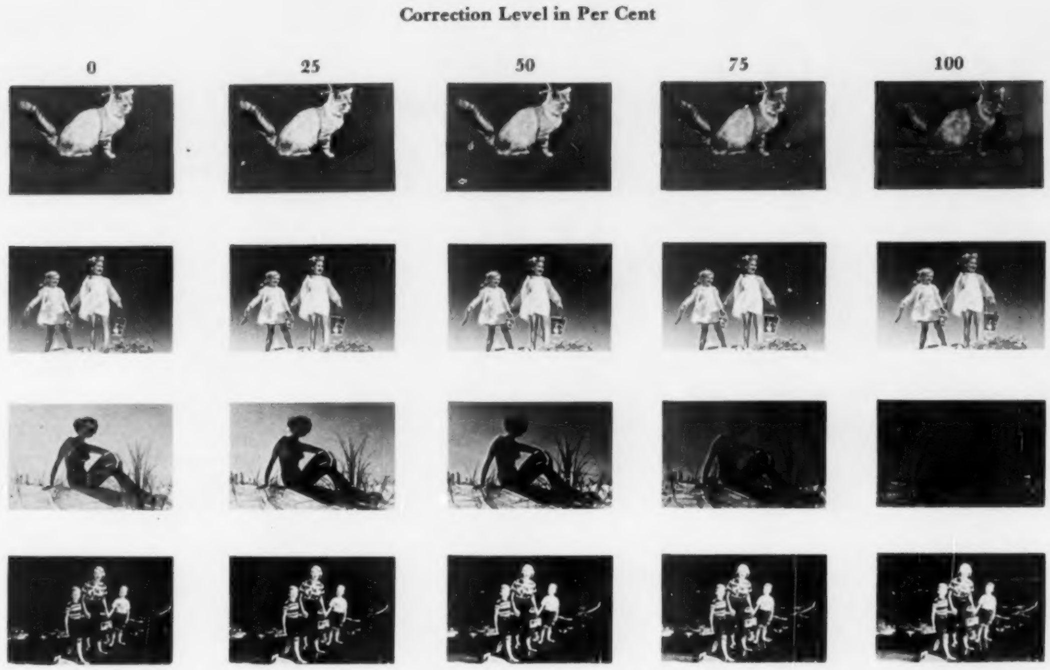

Fig. 3. Effect of correction level on prints from negatives showing subject failure. Best prints are those at lower levels of correction.

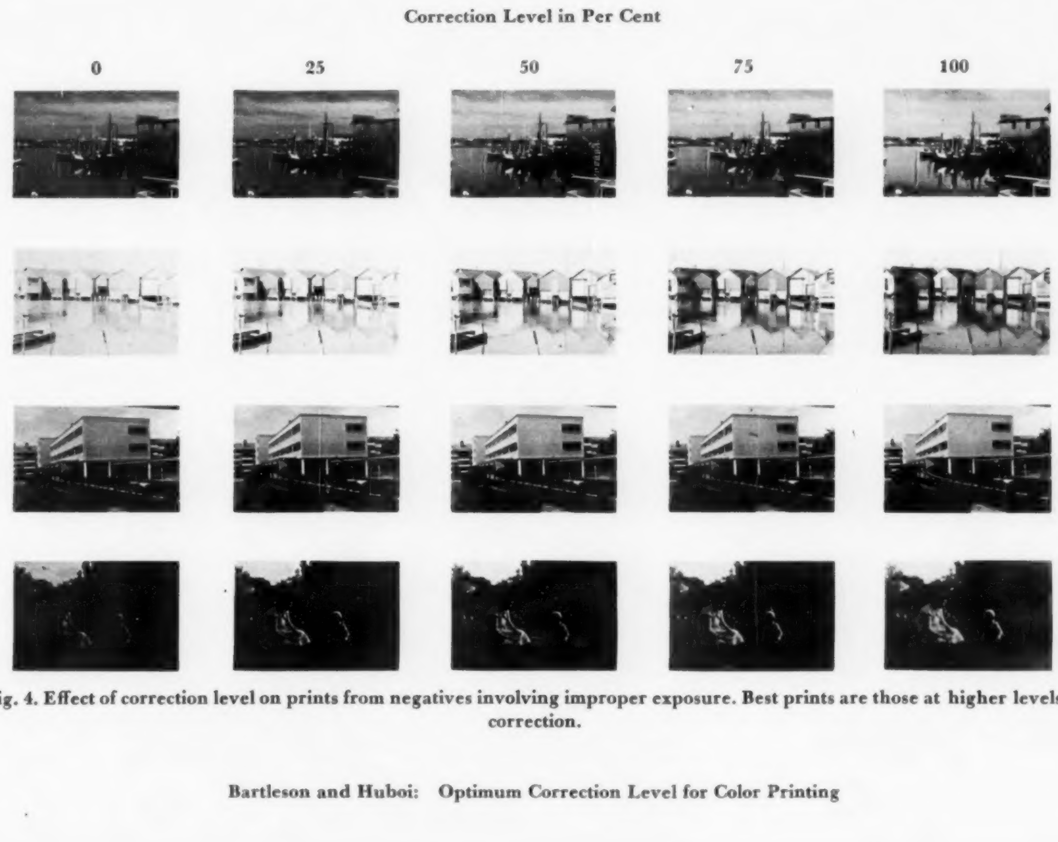

Fig. 4. Effect of correction level on prints from negatives involving improper exposure. Best prints are those at higher levels of correction.

4. C. M. Tuttle, "Photoelectric photometry in the printing of amateur negatives," *J. Franklin Inst.*, *224:* 315–337, 1937.

VII. Exposure Determination Methods Based on Minimum Density

1. L. A. Jones and C. N. Nelson, "Control of photographic printing by measured characteristics of negatives," *J. Opt. Soc. Amer.*, *32:* 558–619, 1942.
2. C. M. Tuttle, "Photoelectric photometry in the printing of amateur negatives," *J. Franklin Inst.*, *224:* 315–337, 1937.

VIII. Exposure Determination Methods Based on Selected Areas of a Negative

1. J. R. Balsey, U.S. Pat. 1,999,556, Apr. 30, 1939.
2. J. M. Centa and J. D. Whidden, "A new optical technique for improving exposure uniformity of automatically timed portrait prints," *Phot. Sci. Tech.*, *2:* 9–10, 1955.
3. R. S. Morse, U.S. Pat. 2,269,161, Jan. 6, 1942.
4. K. Rath, U.S. Pat. 2,444,675, July 6, 1948.
5. W. Stull, "Hollywood Engineer Designs New Type Meter," *Amer. Cinematographer*, May 1939.
6. C. M. Tuttle, R. V. Cartwright and H. P. Eichler, U.S. Pat. 2,464,162, Mar. 8, 1949.
7. L. E. Varden, U.S. Pat. 2,501,365, Mar. 21, 1950.
8. L. E. Varden and J. Robins, "Photoelectric controls for color printing," *Electronics*, *19:* No. 6, 1946.
9. L. E. Varden and P. Krause, "Printing exposure determination by photoelectric methods," *Am. Ann. Phot.*, *64*, 1950.

IX. Scanning Methods

1. P. Curry, U.S. Pat. 2,309,048, Jan. 19, 1943.
2. D. R. Craig, "The LogEtron; A fully automatic, servo-controlled scanning light source for printing," *Photo. Eng.*, *5:* 219–226, 1954.
3. J. R. Gunther, U.S. Pat. 2,560,567, July 17, 1951.
4. J. R. Gunther, "Color correction by electronics," *Amer. Photo. Engraver*, *41:* 1257, 1949.
5. A. C. Hardy, U.S. Pat. 2,434,561, Jan. 13, 1948.
6. A. C. Hardy and F. L. Würzburg, "A photoelectric method for preparing printing plates," *J. Opt. Soc. Amer.*, *38:* 295, 1948.
7. L. C. Jesty, Br. Pat. 631,095, Apr. 18, 1945.
8. P. Mertz and F. Gray, "A theory of scanning and its relation to the characteristics of transmitted signal in telephotography and television," *Bell System Tech. Jour.*, *XIII:* No. 3, 1934.
9. "Details Announced on Time Scanner," *Mod. Lithography*, *18:* 28, 1950.
10. H. E. J. Neugebauer, *Zeit. Tech. Phys.*, *36:* 22–89, 1937.
11. F. Preucil, "Electronic scanners for color correction," *Natl. Lithog.*, *57:* 40–41, 87, 89, June 1950; 28–29, Aug. 1950; 34–35, 90, 91, Sept. 1950; 50–51, 118, Oct. 1950.
12. H. F. Pulitzer, "Colour reproduction," *Funct. Phot.*, *1:* 26, July 1950.
13. A. Simmon, U.S. Pat. 2,499,039, Feb. 28, 1950; 2,565,399, Aug. 21, 1951.
14. B. L. Sites, U.S. Pat. 2,567,240, Sept. 11, 1951.
15. L. A. Thompson, U.S. Pat. 2,415,051, Jan. 28, 1947.
16. A. Weaver, U.S. Pats. 1,709,926, Apr. 23, 1929; 1,814,987, July 14, 1931.

X. Separate Color Exposure Determination Methods

1. R. H. Alder, "Control of color," *Min. Cam. World*, *2:* 441–442, 446, Jan. 1951.
2. F. Biedermann, Ger. Pat. 722,839, appl. July 13, 1940; and U.S. Pat. 2,214,072, appl. Nov. 26, 1938; 2,374,916, appl. Feb. 17, 1942.
3. A. V. C. DeBrie, Br. Pat. 721,547, (filed) Dec. 27, 1951.
4. I. G. Farbenindustrie, Fr. Pats. 882,184, appl. May 20, 1942; 885,182, appl. Aug. 14, 1942.
5. F. P. Herrnfeld, "Printing equipment for Ansco color film," *Jour. SMPTE*, *54:* 454–463, April 1950.
6. F. P. Herrnfeld, "A system for automatic additive printing and scene testing," *ibid.*, *65:* 256–259, May 1955.
7. A. Kochs and R. Gottsch, Ger. Pat. 733,587, appl. May 25, 1939.
8. A. Schilling, "Zum Agfacolor-Kopierprozess," *Film und Farbe*, Berlin, Max Hesses Verlag, 1943.
9. W. Schneider and W. Seebode, Ger. Pat. 742,783, appl. July 5, 1940.
10. L. E. Varden, U.S. Pat. 2,544,196, Mar. 6, 1951.
11. L. E. Varden, "Semi-automatic color analyzer," *Jour. SMPTE*, *56:* 197–204, Feb. 1951.

XI. Miscellaneous

1. J. M. Bing, U.S. Pats. 2,149,250, Mar. 17 1939; 2,201,606, May 21, 1940.
2. G. Bruck, J. Higgins and J. Ward, "Automatic exposure control," *Electronics*, *23:* 74–78, 1950.
3. G. Bruck and J. Ward, "Automatic exposure control," *Phot. Eng.*, *3:* 1–11, 1952.
4. G. Bruck, J. Ward and V. Aske, "Further developments in automatic exposure control for aerial photography," *Phot. Eng.*, *3:* 183–188, 1952.
5. P. Dautzenberg, U.S. Pat. 2,138,445, Nov. 29, 1938.
6. H. E. Edgerton, U.S. Pat. 2,588,368, Mar. 11, 1952.
7. K. Knobel, U.S. Pat. 2,158,903, May 16, 1939.
8. F. C. Whalen, Br. Pat. 491,410, Sept. 1, 1938.

Automatic Timing of Color Negatives

By JOHN G. STOTT, WILLIAM R. WELLER and J. EDWARD JACKSON

Timing of color negatives for release printing has proved to be a tedious, time-consuming, and expensive operation in motion-picture laboratories. Based on methods of exposure determination for printing amateur, still, color negatives, a simple and rapid method has been developed for automatic timing of color negatives. The integrated transmissions to red, green and blue light of the color negative are measured on a full-frame densitometer for a large number of scenes having a wide gamut of subject matter. These integrated transmissions are statistically correlated, scene by scene, to the printer lights that produced acceptable color prints from the color negatives. From these correlations the printer lights that will produce color-balanced prints may be predicted within certain limits from the full-frame, integrated, transmission measurements of an unknown negative. While the color balance of the first print produced by this method may not be considered optimum, the print is close enough to optimum that a skilled color timer can produce a color-balanced print on the second or third trial. Results of a trial at Ace Film Laboratories showed the method to be practical.

A PROFESSIONAL motion picture is composed of many scenes photographed at different times and under different conditions. For obvious economic reasons any scenes in a motion picture which are to be photographed on one set or one location are made in one shooting sequence regardless of the order in which they are finally assembled in the conformed picture negative. A series of scenes photographed on one set on any given day of production may be cut into any or all reels of the completed picture. Differences in "color balance" of the color negative will occur from day to day and from set to set owing to inevitable differences in color quality of the lighting, differences between camera lenses, variations in negative processing, and innumerable other factors. In addition, special effects are introduced in the picture which require duplicating steps. Only under the most rigidly controlled conditions in the duplicating process is it possible to produce an internegative having the same printing characteristics as the original negative from which the internegative was made. For these reasons it is necessary during release printing of a conformed color negative to change the intensity and color quality of the exposing light reaching the printing aperture from scene to scene in order to produce a color-balanced release print.

The operation of determining those printing conditions which will produce a color-balanced print is referred to as "timing," and the people who perform this task are called "timers." Motion-picture timers, after many years of training and experience, develop astonishing skill in timing black-and-white negatives by naked-eye inspection of the negative over an illuminator. Knowing the "scale" of their printing machines, they are able to time a black-and-white motion picture so accurately that an optimum print is achieved on the second or third trial. Unfortunately, this condition does not prevail in timing a color negative. The timer's eye is able to gauge the overall density of a color negative and his mind is capable of performing the inversion which allows an accurate choice of printing light to produce a print which is correct in respect to density. However, he finds the task of inverting cyan-colored flesh on the color negative to a pleasing flesh tone on the print infinitely more difficult, particularly in the presence of colored couplers. Therefore, many more trial prints are generally required to arrive at an optimum color-balanced print. Since this difficulty results in considerable expense and loss of time in a motion-picture laboratory, the need clearly exists for a method of color timing which is more rapid and permits achievement of an optimum color-balanced print with fewer trials. This is particularly true for additive printing, and this paper is concerned primarily with the problems of color timing for additive printing machines.

Presented on January 10, 1956, at the Society's Atlantic Coast Section Meeting at Fine Sound Studios, New York, by John G. Stott (who read the paper), William R. Weller and J. Edward Jackson, Color Technology Div., Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.
(This paper was received on January 31, 1956.)

Automatic Color Timing

Methods of determining black-and-white printing exposure were largely empirical until 1902 when Joseph Poliakoff[1] patented a still-picture printing device with an accompanying method of exposure determination. Poliakoff utilized the total transmittance of a negative; the light was reflected by a mirror onto a piece of actinic paper which in turn reflected light to a selenium cell. As the paper darkened, the cell current was reduced, and at a preselected current value a solenoid closed the shutter. Poliakoff was the first to use information from the entire negative for exposure determination. Other workers have employed characteristics of selected parts of the negative such as density of flesh areas, minimum density, maximum density, and combinations of these. Later these same methods were applied to the printing of still color films and papers. There are many articles and patents pertaining to this problem, and it is beyond the scope of this paper to present the entire bibliography.

The automatic color-timing method described in this paper is based on a patent granted to R. M. Evans[2] in 1951 which describes methods of exposure determination for printing still color pictures. Evans showed that it is possible to determine color and density exposures simultaneously by measuring the integrated red, green and blue transmittance of an entire color negative. The system is based on the assumption that the red, green and blue components of an average negative are nearly equal, and therefore will integrate to a gray or a constant hue. If the total integrated transmittance varies from this gray or constant hue, a change in exposure corresponding to the anomalous transmittance will correct both the density and the color in one operation. This may be represented by three equations for red, green and blue of the form shown in Eq. (1).

$$\log_{10} F_i = k_i + D_i \qquad (1)$$

where

F_i = printer light flux
k_i = a constant
D_i = the density corresponding to the total integrated transmittance of the negative
i = red, green or blue

It is important to note in Eq. (1) that D does not represent integrated density but rather corresponds to $-\log T$ where T is the integrated transmittance of the negative. The constant k is a function of the "aim point" of the process and is constant for only one process and one print emulsion. As the process changes and print emulsions of different speeds are used, k will change.

This method of exposure determination works perfectly only on so-called "average" subjects where the negative has equal amounts of red, green and blue light components. It obviously fails

in the classic example of a person in a red coat photographed standing before a red barn. The red transmittance of such a color negative would be low, and the exposure determination would call for an increased red exposure resulting in a print having cyan flesh tones and a desaturated red barn and coat. This failure to conform to normal integration values is referred to as "subject failure." In this case a better print would result if the integrated transmittance data were totally ignored and the negative was printed at the "aim" condition. Evans recognized this shortcoming and felt that color subject failure could be minimized by giving less than full correction. This may be expressed by three equations for red, green and blue of the form shown in Eq. (2).

$$\log_{10} F_i = k_i + a_i D_i \qquad (2)$$

where

a_i = some constant less than unity

This would mean that those negatives fulfilling the "full correction" criterion (equal amounts of red, green and blue transmittance) would not result in optimum prints by this method, but statistically the majority of negatives in a large population of negatives would produce acceptable prints with fewer rejects for subject failure.

Since this method of exposure determination had proved successful in printing color prints from amateur still color negatives, it was felt that it might prove of value to motion-picture color timing.

However, there are confounding factors which make this method of color timing less applicable to motion-picture color-printing than to amateur still color-printing. First, the acceptability tolerances for amateur prints are wider than those for sequential scenes in a professional motion picture. Second, the patron in the darkened theater is color-adapted to the *picture*, while the viewer of an amateur color print is color-adapted largely to his *surroundings* and to a smaller degree to the picture he is viewing. Relatively small shifts in color balance in the theater from scene to scene, then, are extremely objectionable, particularly at the time of change from one scene to the next and when scenes are short. Third, because of this eye-adaptation effect, this method cannot determine how one scene affects the way the patron sees the following scene, and hence how it should be printed. Any timer will vouch for the fact that the optimum printing condition for a given negative depends upon which scene it follows in the picture.

In order to determine the red, green and blue constants k and a in Eq. (2), a large population of highly different negative scenes would have to be studied. The full-frame integrated transmissions to red, green and blue light of each negative scene would have to be measured and trial prints made until the optimum color balance for each scene had been achieved. The integrated transmissions (or densities for simplicity) of the negatives are then correlated statistically to the printing flux required to produce the optimum print. Graphs can then be prepared from which the optimum printing flux or printer lights can be predicted directly from the measured densities of the negative. For additive printing, three graphs would be prepared for the three printer lights. The line on each graph has the property of being the "best fit" for all of the data available. The graph is most accurate and useful when a large number of scenes have been studied and when the data plotted are those for the best possible color prints from the negatives. The mathematical method of determining the line that is the best fit to the data is described later. For subtractive (white light) printing a similar method can be applied for predicting the densities of cyan, yellow and magenta color-correcting filters required in the light beam of the printer.

It is imperative that this method be thought of not as a means of timing a color motion picture so that an optimum print will be produced on the first try. The best that can be hoped is that a first print can be made from the timing predictions determined by this method that will have most of the scenes close enough to optimum color balance that a skilled timer can take over from this print and produce an improved second print and an optimum print perhaps on the third or fourth trial.

Instrumentation

The first problem to be solved in applying this method of color timing was the matter of measuring the full-frame integrated transmittance of the negative. The full-frame densitometer required the following:

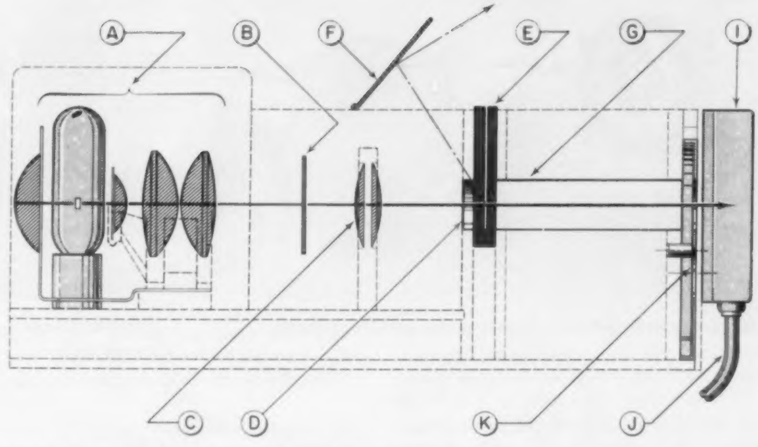

Fig. 1. Schematic of 35mm Full-Frame Densitometer.

1. A measuring aperture that holds the negative film firmly in place during measurement without damaging the negative.
2. A uniformly illuminated measuring aperture.
3. Sufficient illumination to measure the complete negative density range.
4. A photocell and filter combination that will give effectively the printing densities of the color negative on the color print film.
5. A light-integrating system that "scrambles" the light transmitted through the negative into light of a uniform distribution at the photocell.
6. A photocell and meter combination that is accurate and reproducible.
7. A reasonably simple and easy method of operation.

The full-frame densitometer developed for these studies is shown schematically in Fig. 1. The light source (A) is the lamp housing and optics of a conventional slide projector equipped with a 100-w bulb. A dichroic filter (B) is used to reflect the infrared light in the beam. The printer aperture (D) is uniformly illuminated through a relay lens (C). The aperture has full CinemaScope dimensions with provision for masking the soundtrack area when Academy-aperture negatives are being measured. The film gate (E) is plush-lined and the jaw of the gate nearest the light source is hinged to permit rapid and safe insertion and removal of the negative. A sheet of highly polished stainless steel (F) is hinged above the hole in the top of the illuminating tunnel and functions as a mirror to permit accurate positioning of the negative frame in the aperture. Directly behind the aperture, positioned about $\frac{1}{16}$ in. from the negative, is a Lucite integrating bar (G). The bar is rectangular with 35mm CinemaScope aperture dimensions, and both ends are sanded. A three-position filter wheel (K), with detent-stops, filters the light emerging from the integrating bar. The

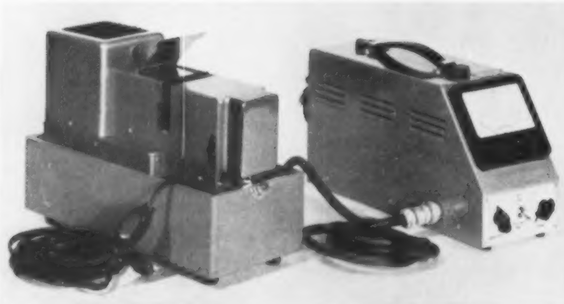

Fig. 2. 35mm Full-Frame Densitometer and Densichron.

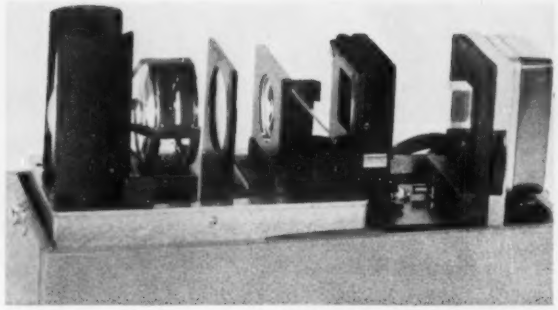

Fig. 3. Densitometer with cover removed to show details of construction.

photocell is a standard Densichron Blue Probe (I), and (J) is the cord leading to the meter, a standard Densichron, Model 3830A (both manufactured by Welch Scientific Co., Chicago). The filters (K) used in the densitometer are Status K as used in the Eastman Electronic Densitometer, Model 31A, which will produce density readings in good agreement with printing densities from Eastman Color Negative Film, Type 5248, to Eastman Color Print Film, Type 5382. Neutral density filters are mounted with the color filters to balance the red, green and blue readings at zero with no film in the gate.

The accuracy of the instrument was determined as follows. A series of Munsell gray chips from dark gray to white was photographed in a camera on Eastman Color Negative Film, Type 5248. Exposures were chosen to give a complete density range. The processed exposures were measured on an Eastman Electronic Densitometer, Model 31A, at several places on each frame, and the values for each frame were averaged. The frames were then positioned in the full-frame densitometer and were measured. The agreement in measured density values between the full-frame densitometer and the average of the Model 31A measurements was within 0.02 density units for red, green and blue over the entire scale. This accuracy was judged to be sufficient for these studies.

The procedure in measuring a full frame of motion-picture color negative is as follows:

1. Zero the instrument through each of the three filters.
2. Insert the color negative in the aperture with the emulsion facing the light source and position the frame accurately in the aperture. Close the gate jaws.
3. Measure the density of the color negative to red, green and blue light through the three filters.
4. Open the gate jaws and remove the color negative.

Figure 2 shows the full-frame densitometer and Densichron. Figure 3, the full-frame densitometer with the cover removed, shows the detail construction.

Experimental Procedure

In order to obtain a large number of negative scenes of widely different characteristics to use for determination of the red, green and blue constants k and a of Eq. (2), outtakes from several feature motion-picture productions were obtained. The integrated transmissions to red, green and blue light of these negatives were measured, and the negatives were spliced together for printing at a variety of printer-light balances on an additive printing machine at Kodak Park. It soon became apparent that the same difficulties facing a motion-picture timer in the professional motion-picture laboratory had to be faced in preparing optimum prints from these clips. While this method could and has been used for making the best color-balanced prints from the negative clips, the procedure is time-consuming and tedious, and the data obtained are applicable only to the printing machine and process at Kodak Park.

Since any motion-picture laboratory must go through a trial-and-error method of making an optimum release print, it seemed evident that the matter of data-taking for this project could be more rapidly accomplished in a professional motion-picture laboratory. Accordingly, permission was requested of Mr. Joseph Spray, President, Ace Film Laboratories, Brooklyn, N.Y., to conduct experiments at that laboratory. Mr. Spray graciously granted this permission, and the full-frame densitometer was taken to Ace. Negatives were supplied from feature motion pictures on which release printing was finished. The densities of the negative scenes to red, green and blue light were measured, and the timing data that produced optimum release prints at Ace Film Laboratories for these scenes were recorded from the production time cards. Ace Film Laboratories employs additive printers having three separate light sources. The red, green and blue light is mixed by means of a dichroic filter arrangement. Five neutral density filters having values of 0.025, 0.05, 0.10, 0.20 and 0.40 are available for each light source. The neutral densities are rapidly placed in the printing beam by means of solenoids cued from a punched tape or a special light board. Hence, the total range of neutral density filter combinations for each light on these printers is 0 through 0.775 in 0.025 increments. In this instance the neutral density values of the filters represent log E changes of the printing-light intensity for any one light. The method of mathematical treatment used to correlate the density of the negative with the printing data does not require that the printing data be expressed in terms of log E values. The printing data may be expressed in any terms convenient to the particular laboratory involved whether they be log E values, neutral density values, or arbitrary numbers or even letters.

Over 750 negative scenes from five feature motion pictures were measured at Ace Film Laboratories, and the printing data for these scenes were recorded. At first glance this population of negative scenes would appear to be large enough for a meaningful statistical analysis of the data. While subsequent use of the data from this survey proved to be adequate to demonstrate the validity of the method, the authors feel that a population in excess of 2,500 scenes from more than ten feature pictures would have provided even more accurate data.

The data taken at Ace Film Laboratories were brought back to Kodak Park in Rochester for mathematical analysis.

Mathematical Treatment

To determine the red, green and blue coefficients a and k from the data taken, it is first necessary to investigate the relationship between the densities of the negatives and the optimum printing conditions for several motion-picture productions. Each production is studied separately first, since the relationship between negative densities and printer light is affected by many sources of variation such as subject matter, print emulsions and process variability.

The first step in studying a given motion picture is to plot the data in the form of scatter diagrams for each color (i.e., plot printer light vs. density of negative, as shown in Fig. 4, for each color). These plots should then be carefully studied for instances where individual scenes do not conform to the general population of scenes. This aids in the discovery of clerical errors in recording the data or errors in densitometry. Extreme cases of subject failure or unusual lighting effects such as night scenes which must be printed in a special way should be deleted at this point. Unless internegatives have been made with the greatest care and control, they also should be treated separately.

It is often worth while to break these plots down into individual reels or perhaps by exterior and interior scenes to gain some insight into any additional sources of variability which might be present in the system. Differences between exteriors and interiors might indicate that exteriors would have to be printed with different coefficients from those for interiors, although this was not found to be true for the motion pictures studied at Ace.

After this editing, the remaining data represent the population of scenes that will produce acceptable prints without introducing special conditions.

For automatic color timing, an equation is required to predict (within certain limits) how an unknown negative should be printed once the densities of the negative have been measured. The desired prediction is of the form shown previously in Eq. (2). However, this may be simplified to three equations for red, green and blue of the form shown in Eq. (3) since the printer light, regardless of how it is expressed, is a measure of the logarithm of the light flux.

$$\text{Printer light}_i = k + a \text{ (negative density)} \quad (3)$$

where i = red, green or blue

The red, green and blue coefficients k and a can be determined by the method of least squares. The derivation of the formulas for computing these coefficients is beyond the scope of this paper but is amply described in the literature.[3] However, the following example will illustrate the computations for a particular reel used in the study at Ace Film Laboratories. The equation to be derived is for the blue printer light as a function of the density of the negative to blue light. There were forty scenes in the reel, of which two were internegatives, and these data were deleted. The data and computations are as follows:

Scene No.	X *Blue negative density*	Y *Blue printer light*	
1	1.79	0.225	
2	1.78	0.200	
3	1.52	0.300	
4	—	—	(Internegative, Delete)
5	1.72	0.175	
...	...	...	
...	...	...	
...	...	...	
38	—	—	(Internegative, Delete)
39	1.95	0.175	
40	1.55	0.300	

$\Sigma X = 67.48$ $\quad \Sigma Y = 7.075$

$\Sigma X^2 = 121.0818$ $\quad \Sigma Y^2 = 1.546875$

$\Sigma XY = 12.09100$ $\quad n = 38$

$$k = \frac{\Sigma X^2 \Sigma Y - \Sigma X \Sigma XY}{n\Sigma X^2 - (\Sigma X)^2} = \frac{(121.0818)(7.075) - (67.48)(12.09100)}{(38)(121.0818) - (67.48)^2} = 0.856913$$

$$a = \frac{n\Sigma XY - \Sigma X \Sigma Y}{n\Sigma X^2 - (\Sigma X)^2} = \frac{(38)(12.09100) - (67.48)(7.075)}{(38)(121.0818) - (67.48)^2} = -0.377707$$

The best calculated prediction equation then is:

$$\text{Blue printer light} = 0.857 - 0.378 D_B \quad (4)$$

To locate the line on the graph, it is necessary only to substitute any two negative density values in the equation, solve the equation for the printer light, plot these two points on the graph, and draw a straight line through the points. This mathematically fitted line is called the *regression line of Printer Light on Negative Density* and will be the best straight line through the data in the sense that it minimizes the sum of squares of the deviations about the line in terms of *printer lights* which is the variable to be predicted. In addition, it is necessary to obtain a measure of how well this regression line will predict the printer lights. This measure is called *the standard error of estimate*, $s_{Y \cdot X}$.

$$s_{Y \cdot X} = \sqrt{\frac{\Sigma Y^2 - (k\Sigma Y + a\Sigma XY)}{n - 2}} = 0.0377 \quad (5)$$

This is essentially the standard deviation of the observed printer lights about the regression line and should represent the inherent variability of the system and should include such variables as printer repeatability, print film nonuniformity, within-process variability, densitometer variability, and the ability of the inspector or timer to determine the optimum print. If all the points cluster closely about the line, the standard error of estimate, $s_{Y \cdot X}$, will be small; if they are widely dispersed, it will be large. It is, therefore, essential that all of the above-mentioned cases of extreme subject failure, internegatives, etc., be deleted before calculating the regression line, as these extraneous values would affect the estimates for both k and a and would affect $s_{Y \cdot X}$ adversely.

It can be shown that the prediction limits about the regression line are actually hyperbolic in nature, since both k and a are estimated from a sample and are subject to error.[3] Proof of this fact is beyond the scope of this paper. In fact, for a moderate sample size they are sufficiently parallel to the regression line so that plus or minus twice the standard error of estimate ($\pm 2\, s_{Y \cdot X}$) may be used as an approximate measure of the limits within which 95% of the predictions should fall, assuming the distribution of these predictions about the line is normal and that no prediction will be made beyond the range of negative densities from which this relationship was determined (i.e., extrapolation). Roughly 95% of all the scenes in this particular reel fall within ±0.075, or plus or minus three printer lights of the line represented by Eq. (4). The actual 95% prediction limits are shown in Fig. 4. With a sample size of 38 and a small standard error of estimate, over this range, the limits are

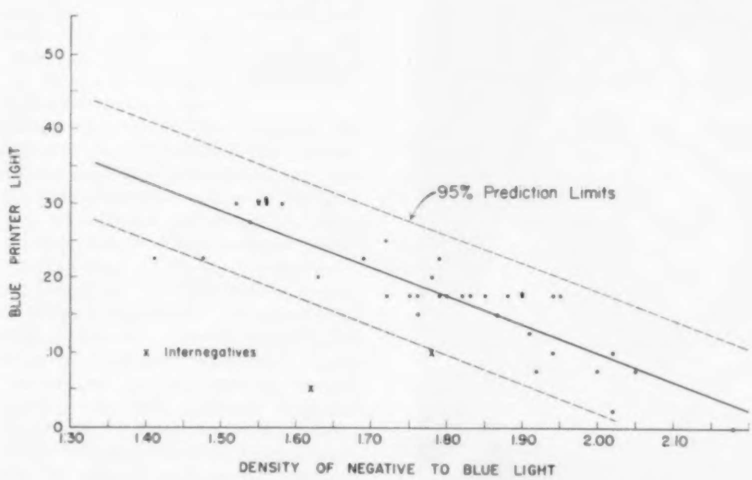

Fig. 4. Relationship between blue negative densities and blue printer lights for a typical reel of motion pictures.

practically straight lines. Only one observation is outside the limits.

The intercept, k, is a function, among other things, of the print emulsion used and the process level at the time; any comparison of the intercepts from one production to another will reflect mainly differences in these two variables. The printing coefficient, a, is a function of these two variables only with regard to contrast and is therefore primarily a function of the subject material. Since few productions include all types of scenes, several productions should be studied *separately* and average printing coefficients obtained from these. If this were not done and the data from all productions pooled, the effect of emulsion differences, etc., would be incorporated, and the standard error of estimate would be meaningless.

In the project at Ace Film Laboratories, more than 750 scenes from five motion pictures were studied. The gamut of scenes covered by these five productions was fairly wide. When the results of these productions were averaged, the prediction equations (rounded to the nearest 0.05 for simplicity) were as follows:

$$\text{Red printer light} = k_R - 0.40D_R \quad (6)$$

$$\text{Green printer light} = k_G - 0.45D_G \quad (7)$$

$$\text{Blue printer light} = k_B - 0.35D_B \quad (8)$$

The k's were not evaluated as they have little meaning except for these five productions, printed on the particular print emulsions used to make the trial prints from which the optimum printing conditions were determined.

Graphs were then prepared from Eqs. 6, 7 and 8 to be used to predict printing conditions for an unknown motion-picture negative. The negative density values are plotted along the abscissa and the printer lights along the ordinate. The predicting line is in the form of a high-contrast photographic overlay. Placement of the overlay on the graph with the horizontal line parallel to the abscissa has the effect of fixing the constant, a, in Eq. 3 but allowing k to be varied at will, depending on the print emulsion and process being used at the time of predicting and on the general speed anomalies in the negative. Figure 5 shows the photographic overlay in position over the graph. Graphs for red and green prediction were prepared in the same manner but are not shown.

It is quite possible in subtractive printing that unwanted absorptions in the subtractive filters will make it necessary to use red, green, and blue density measurements to predict optimum printing conditions. As an example, Eq. 9 illustrates how to determine what value of color-correcting filter should be in the light beam to produce a color-balanced print.

$$\text{Value of color-correction filter} = k + a_1D_R + a_2D_G + a_3D_B \quad (9)$$

The coefficients k, a_1, a_2, and a_3 can all be obtained by the method of least squares using multiple regression equations.[3] The initial computations are somewhat more lengthy, and the actual timing operation is also more involved, but neither is beyond the realm of practicality as far as actual production is concerned. The printer lights can be determined by use of an analog computer, for example, or by use of a prepared table.

Since no two laboratories have the same printing and processing facilities, these equations should not be expected to hold anywhere except at Ace Film Laboratories. Each laboratory would have to perform a separate study to determine its optimum printing coefficients. These studies would be made in the same manner as the one described here—determination of the relationship between the negative densities and the optimum prints obtained from the negatives for many scenes from several productions—and then obtaining an average coefficient from these with which all normal negatives can be printed.

As new experience is gained in the use of this method of color timing, more sophisticated interpretation of the data may be employed. More accurate prediction of the optimum printing conditions may be possible if different slopes on the graphs are used for different types of pictures. A dramatic "mood" type of picture having a majority of low-key scenes perhaps may be more accurately timed by this method using a lower slope than illustrated here, since more of the scenes fall in the "subject failure" category. A musical comedy picture featuring brightly lighted scenes liberally laced with color may be predicted more accurately with a higher slope graph, since a majority of the scenes would tend to fulfill the criterion of containing equal amounts of red, green and blue components. It is conceivable that long experience with this method of color timing will result in the use of different graph slopes for different cinematographers which would reflect the care with which the cinematographer determines exposure and his propensity to employ extremes in dramatic lighting. This does not detract from the value of this timing method for all types of pictures shot by many cinematographers. The aforementioned comments point only to refinements and improvements of the method which may be developed when infinitely more experience has been obtained than is now available to the authors.

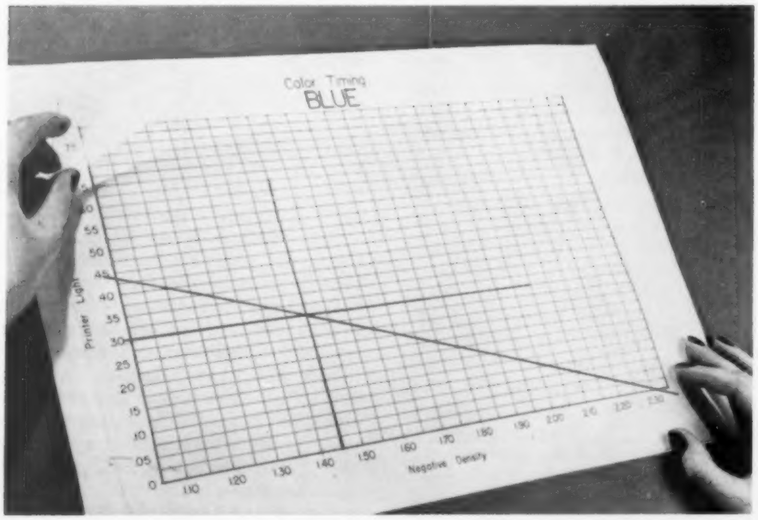

Fig. 5. Transparent overlay ($a = -0.35$) in position over the graph.

Results

Again with the permission of Mr. Spray, seventeen full reels at Ace Film Laboratories were timed using the computed data. These reels included a one-reel short subject, a four-reel short subject, and a twelve-reel feature. The following is the procedure used to time the four-reel short subject:

1. It was first necessary to determine the placement of the overlays on the graphs for preliminary trial prints. Ace Film Laboratories employs a closeup of a girl as a test negative to assist in balancing production printers to each other. This test negative is always printed at red printer light 0.30, green printer light 0.30, and blue printer light 0.30. In this case 0.30 represents a value of 0.30 neutral density over each light source. Prints made periodically from this negative on each printing machine are examined visually, and any printer which is off color-balance is corrected by adjustment of the voltage applied to the separate lamps. The density of this test negative to red, green and blue light was measured, and the overlays

were placed on the graph so that the vertical line was at the measured density value of the negative for any one color and the horizontal line was at the 0.30 printer light. As shown in Fig. 5, the overlay is placed with the vertical line at 1.45 (blue density of the test negative) and with the horizontal line at 0.30 (the blue printer light at which this test negative is always printed). *This, then, represented the predictive situation when the original data were taken*, in this case several weeks previous.

2. The next task was to determine whether the same predictive situation existed for the print emulsion and process in use at the present time and for the particular negative to be timed. One reel of the short subject was selected for preliminary tests. A reel other than 1-A was chosen since main and credit titles do not yield particularly accurate information on the overall balance of test prints. The selected reel, however, should include a fair gamut of scenes and most certainly should include internegatives.

3. All of the scenes in the selected reel were measured on the densitometer. Only one frame for each scene was measured and that one was chosen to be about ten frames from the head end of the scene.

4. From the measured densities the printing lights for about 15 or 20 scenes at the beginning of the reel were determined from the graphs with the overlays in the predictive position for the test negative.

5. These scenes were printed at the predicted printer lights. The processed print was then examined for an overall trend of color balance in one color direction. It was determined that the prints from original negatives showed an overall magenta color balance of about 0.05 and were slightly light. Accordingly, the overlays were adjusted on the graphs by dropping the horizontal line for the blue and red overlays to printer light 0.25 while leaving the green at printer light 0.30. This had the effect of darkening the print and removing the magenta shift. By the same method, a second set of graphs was prepared for internegatives in which the horizontal line for the red overlay was adjusted at printer light 0.125, the green overlay to printer light 0.225, and the blue overlay to printer light 0.375. It was hoped that this separate adjustment would produce prints of acceptable color balance from internegatives.

6. All scenes for all reels were then measured on the densitometer, and the printer lights for all scenes were determined from the graphs with the overlays in the adjusted positions. The original negative graphs were used for all original negative scenes, and the internegative graphs were used for all internegative scenes. No previous information is necessary to discriminate original negatives from internegatives since they can be readily selected by a brief inspection of the negative frame lines.

7. *The entire four-reel short subject was then printed at these predicted printing conditions with no further testing.*

The prints produced by this timing method were examined by projection. It was the opinion of the authors that about 50% of the scenes in these reels required no further color correction, 40% of the scenes could be readily corrected on the second print by an experienced timer, and the remaining 10% of the scenes were close enough that an optimum print could be achieved on the third trial.

Those scenes which were not in color balance were mostly internegatives. However, many of the scenes requiring no further correction were also from internegatives, which indicates that a shift in aim point for predicting how these scenes should be printed works satisfactorily. This emphasizes that if all internegatives in a given picture are made alike, whether they match the original negatives or not, it is possible to predict how these internegatives should be printed.

Surprisingly, few scenes showed extreme "subject failure." This is perhaps due to the low correction coefficient determined by the original experimental data, which indicates that anomalies in exposure and latent-image keeping are less important in printing exposure determination than is "subject failure" introduced by the efforts of professional cinematographers to create mood lighting and special dramatic effects in feature motion pictures.

An identical procedure was used to time the one-reel short subject and the twelve-reel feature motion picture. Small adjustments had to be made in the position of the overlays for the original negatives and internegatives of the two different subjects, but these adjustments were of the order of ± 0.05 for any one color.

Once the new aim point had been determined, the time required to measure the negative on the densitometer, determine the printer lights from the graphs and prepare the printing time cards averaged less than $1\frac{1}{2}$ hr per reel for a team of two people. The entire timing procedure for the twelve-reel feature including aim point determination, densitometry, and prediction required a total working time of less than 12 hr for the timing team of two persons, neither of whom was a professional timer.

Conclusions

The true measure of whether this method of timing motion-picture color negatives is helpful to a color timer is the value placed on it by a timer who has seen the method work. The authors discussed this point with Mrs. Mae Geller, Chief Timer at Ace Film Laboratories, without whose splendid cooperation this project would never have been possible. It was Mrs. Geller's opinion that this method of color timing was of great value to the operations at Ace Film Laboratories and would result in substantial savings of time, money and toil.

Acknowledgments

The authors are deeply indebted to R. M. Evans, Director of the Color Technology Division, Eastman Kodak Co., whose original concept of the color exposure determination method made this project possible. The assistance of C. J. Bartleson and R. W. Huboi, also of the Color Technology Div., in explaining the theory of the method and interpreting the data has proved invaluable. John R. Turner is responsible for the development of the densitometer and for many invaluable suggestions as to how this project should be approached. Finally, the authors owe a debt of gratitude to Joseph Spray of Ace Film Laboratories who made his facilities available to us for these experiments, and to Mrs. Mae Geller, also of Ace, whose cooperation, help and suggestions were vital to the success of this project.

References

1. U.S. Pat. 200,083, May 13, 1902 (Poliakoff).
2. U.S. Pat. 2,571,697, Oct. 16, 1951 (Evans).
3. George W. Snedecor, *Statistical Methods*, Iowa State College Press, Ames, Iowa, 1946, Ch. 6, 7, 13.

Military Theater Equipment Modernization

By ROBERT A. HAINES

A comprehensive modernization program of 35mm projection and sound equipment has been executed for its 120-theater military circuit by the Far East Army and Air Force Motion Picture Service. High standards of performance capabilities consistent with limitations imposed by available facilities and film product for overseas areas were established. To meet the concept requirements of quality professional equipment operated by nonprofessional servicemen projectionists, some original designs have been achieved in modification of existing commercial equipment and development where no counterpart has been available from trade supply sources.

The Far East Army and Air Force Motion Picture Service is a quasi-governmental, self-supporting agency serving military personnel in the Orient. Established in 1946, it provides 35mm entertainment motion-picture service in more than 120 fixed theaters, and services over 650 smaller unit accounts with 16mm sound projectors and reduction prints of feature and short subjects. To meet the command policy of five program changes weekly, 260 features are required annually, with five 35mm prints and twelve 16mm prints of each booking being necessary to satisfy the voracious movie appetite of the military forces in the Far East.

The technological revolution, which bestirred the motion-picture industry beginning in late 1952 after the initial success of Cinerama, provided the impetus for a complete and sweeping modernization program in FEAAFMPS 35mm theaters. All existing equipment was over ten years old, mostly surplus from World War II garrison employment. Careful study, and discussion with numerous industry representatives visiting Tokyo, indicated that modernization planning should be based upon the concept of "more light on larger screens." It also was obvious that new equipment should provide, in addition to best possible performance characteristics, a considerable degree of flexibility with respect to accommodating further industry technical developments still being churned up in the revolution.

Military overseas theaters are normally multipurpose structures serving all needs for group assembly. Average seating capacity is under 500. A few seat upwards of 1000, and the 2600-seat Ernie Pyle Theater in Tokyo, now reverted to commercial operation, was an outstanding exception to prove the rule. Permanent-class facilities, properly designed and constructed for theater use, are extremely few in number, particularly on foreign soil, where American military tenure may be highly indefinite. Design factors such as suitable proportions, good sight-lines, satisfactory acoustical conditions, and even adequate ventilation must frequently be de-emphasized in providing *any* sort of needed theater service. Other factors, normally insignificant in stateside theater design, may loom very important in overseas service. Examples are availability of suitable electric power, adaptability of the structures to other military purposes, and availability and turnover rate of qualified projectionist personnel. In the following paragraphs the various factors involved in our modernization planning are discussed in the hope that the information will be useful to other organizations faced with similar problems.

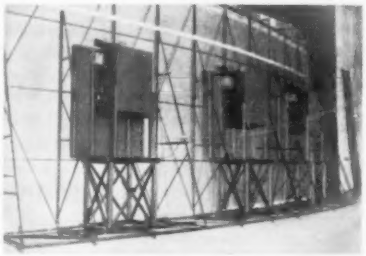

Fig. 1. Rear view of typical mobile screen frame assembly showing platform mounted Ampex type 5050 Reproducer sets. Screen is a 37-ft width Bodde type "B" seamless, with center axis brightness gain factor of 2.9 × (as compared to perfect diffuser).

Screens, Frames and Brightness Levels

The largest practical screen size for each theater was determined by individual survey. Seamless specular screens were selected to realize high axis brightness and because surveys indicated lateral viewing angles generally to be under 30°. Curved, mobile screen frames were designed to improve light distribution and to allow stage clearance for other activities. Stage loudspeaker systems are mounted within the frames for structural balance and good sound transmission. Figure 1 illustrates the back side of a typical installation.

For reasons to be discussed in connection with sound equipment, screen proportions were chosen to accommodate the 2.35 : 1 optical CinemaScope aspect ratio. However, in no instance was potential screen height permitted by existing proscenium construction sacrified merely to achieve the widest possible image. This policy and its corollary, that no image height would be reduced below that previously employed for conventional projection, required comparatively few proscenium alterations.

The desired initial center screen brightness, with 75% side-to-center distribution, was set at 20 ft-L to allow for screen deterioration and less than optimum projector operation and local maintenance. Spot checks with a brightness meter in completed large and small installations indicate that this design goal has been generally achieved.

Image Dimensions and Aspect Ratios

Projection conditions in military theaters preclude the use of numerous interchangeable optical elements and complex variable screen masking to accommodate the various wide-screen systems. Productions from all studios nevertheless must be run to secure the necessary number of program changes. In the present instance the problem has been satisfactorily solved by using variable-ratio prismatic anamorphosers, and variable-focus projection lens attachments to allow all pictures at a given installation to be projected to the same height. These assemblies are readily interchangeable on hook-type brackets affixed to the projector mechanisms. Prime lenses, which remain in place, are selected to produce the standard image height from the CinemaScope apertures, and to match optical speed of the arc lamps in use. The variable-focus attachments allow the 1.75 : 1 aperture which was selected as the best compromise for wide-screen projection of nonanamorphic standard prints, also to be imaged at the standard height. Fortunately aperture centerlines for the various types of prints closely coincide, so only the apertures, the lens attachments, and the screen draw-curtains need to be changed in

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(Revised paper combining the essence of the original papers, received on March 5, 1956.)

going from one type of projection to another. Top and bottom screen roll-off masking, and the draw-curtains are pearl-gray velveteen, which provides some advantages of synchronized screen surround lighting, and is practical from the viewpoint of other military stage uses.

Light Sources

Having established the relatively high screen brightness standard previously noted, simple calculations indicated that it could be produced on the selected screens of various widths by only two arc-lamp types. Simplified high-intensity nonrotating carbon lamps operating at 60 amp are used for all screens up to 30-ft wide. The same lamps operated at 70 amp are used for screens in the width range of 30–50 ft. Screens of 37- to 45-ft width are illuminated by rotating positive, angle-trim reflector lamps operating at 90 amp.

Motor-generator arc power supplies are generally impractical for overseas use, and d-c mains are nowhere encountered in the Far East. Fortunately, newly developed 6-phase secondary, fullwave selenium arc rectifiers originated in Japan became available in time to be selected for this modernization program. They operate from the 200- to 220-v, 3-phase power circuits commonly found and deliver rated arc currents with a measured ripple content of only 1.6%. Resulting arc operating is steady and quiet, and flicker in the projected images is negligible in spite of their brightness. Two of the larger units for 90-amp arcs are shown installed in Fig. 6.

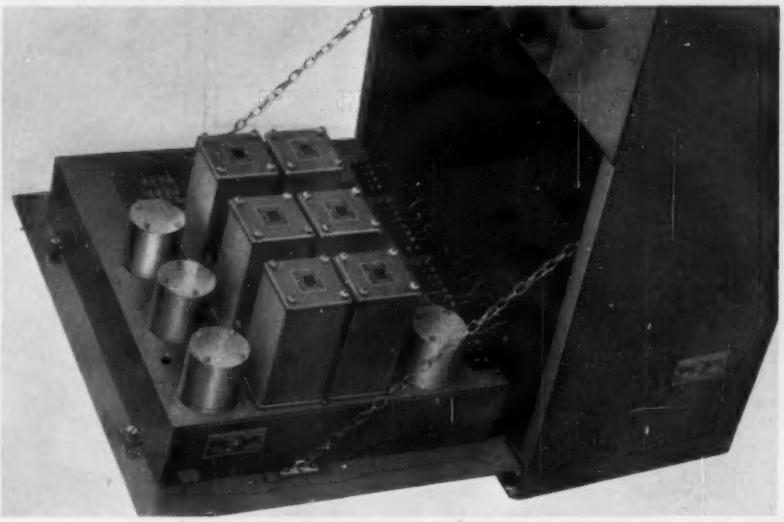

Fig. 3. The AM-8002-B Integrator Panel lowered to service access position shows carrier frequency shift slide switches. Removal of two thumbscrews at front edge of chassis permits reverse turnback of pan for full access to under-chassis components.

Sound Systems

As a basic operational principle, military motion-picture service organizations endeavor to provide the same quality of picture and sound in all situations. Equipment standardization not only conforms to this principle, but also facilitates operation by constantly changing personnel and reduces maintenance costs. Standard commercial projector mechanisms and optical soundheads of recognized quality were therefore selected for all theaters. It long since has been found in military theater service operations that the best equipment proves also the cheapest in the long run. A typical projector assembly is shown in Fig. 2.

A majority of the 35mm prints currently available to overseas operations carry either single-channel, or Perspecta directional optical soundtracks. This practice directed the present installation of reproducing equipment only for such soundtracks, but the sensible proviso was kept in mind that sound equipment selected should provide a ready basis for later conversion to magnetic stereophonic sound when and if distribution patterns change.

Available Perspecta Integrators did not include sufficient emergency facilities to insure continuity of performance in the the remote situations normal to overseas operations. Furthermore, they did not include facilities for useful operation and control of the side channels in the absence of control tones from normal single-optical soundtracks. The Japanese Perspecta licensee cooperated in the design and production of military models which do meet such requirements. The first version, shown installed in Fig. 2, included manually controlled tone oscillators to simulate the Perspecta control frequencies. Vertical attenuators for the two side channels identify this portion of the assembly. Immediately below is a panel supporting dual preamplifiers. Normally one is connected to each soundhead, with changeover being effected by switching the appropriate output circuit to the Integrator input circuit. Emergency operation on one preamplifier is provided by another rotary switch which allows the input of either preamplifier to be connected to the output of either soundhead, thus transferring to this switch the changeover function.

Preamplifiers incorporate internal gain controls and phototube polarizing voltage potentiometers for machine balancing. The integrator proper occupies the lower portion of the cabinet. Its circuitry has been previously described in the

Fig. 2. Typical installation view of PAM-8002-A Perspecta Integrator assembly with Pushbutton Controller panel. Lefthand assembly comprises Simplex X-L, RCA MI-9030-BC and Strong Mighty "90" on LL-1 Heavy-Duty Pedestal.

literature. The present version is standard except for the mechanical layout shown in Fig. 3, and the inclusion of small slide switches on the top of each filter can to shift bandpass filter characteristics downward 4 cycles to accommodate the chronically low power line frequencies encountered in many portions of the Far East. Independent, dual power supply units for the preamplifier and integrator panels are located on the right side of every main amplifier cabinet.

Manufacturing and operating experience acquired from application of the first 25 equipment sets produced and installed allowed considerable design simplification, cost reduction, and improved performance and reliability in an additional 78 sets required. Control tone oscillators were discarded in favor of direct bias control of each integrator side-channel, variable-gain output stage during manual operation of the 3-channel system. Preamplifiers, and the changeover and emergency switches, were moved up into the space vacated by the oscillators, reducing overall cabinet height by $5\frac{1}{4}$ in. as shown in Fig. 4. A third position was added to the changeover switch to handle a permanently connected record player circuit in this more convenient manner as compared to the plug-and-jack arrangement in the first model. The preamplifier-control panel pulls forward on rails and tilts downward on hinges to provide the ready service accessibility shown in Fig. 5. Preamplifiers are located at either side of the chassis pan. Next inward are the vertical attenuators which provide manual control of side-channel gain, and which are internally illuminated whenever they are advanced from the infinite attenuation setting. The ganged master gain control for the three-channel sound system is in the center.

Fig. 4. Front view of PAM-8002-B Integrator with latest series Controller.

The initial Integrator's toggle control switches have been replaced by a three-position rotary master function switch and indicating pilot lamps. In its "Perspecta" position the integrator functions normally for Perspecta soundtracks, including automatic reversion to single-channel operation on control tone interruption. In the "Manual" position side-channel gains are controlled by the two vertical attenuators. In the third "By-pass" position, both indicator lights re-

Fig. 5. View of PAM-8002-B Integrator with Preamplifier panel drawn outward and turned down for service adjustments and access to internal Cabinet terminal board.

Fig. 6. Typical installation view of Ampex APX3-30 Sound Cabinet Rack and a pair of Sansha SRH-100-GX 100-ampere Projection Selenium Arc Rectifiers.

main dark and integrator circuits are entirely bypassed through a simple gain-equalizing network connecting the preamplifier output directly to the center channel main amplifier input circuit, an important emergency feature considering the number of tubes and components in the integrator.

American-made power amplifiers, exciter lamp power supplies and monitoring panels are mounted in cabinet-type racks as shown on the left in Fig. 6. The lighter-finish panel near the bottom is a custom-built automatic line voltage regulator. Far Eastern power circuits are unfortunately subject to both poor voltage regulation and poor frequency regulation, the latter ruling out the use of resonated voltage regulators. Little can be done about the frequency shifts other than to provide correct drive-gear ratios for the nominal frequency, together with measures already described in the integrator circuits to accommodate subnormal control frequencies. Electromechanical voltage regulators can provide very steady voltage, however, and radically reduce cases of poor performance and equipment failures caused by low line voltage or heavy surges. The regulators incorporate a line sampling unit consisting of thyratrons in a bridge circuit which controls through relays a 2-phase servo motor geared to a variable autotransformer. This in turn is coupled to a line transformer and reactor to add or subtract corrective voltages as required. Output voltage is maintained at any selected value between 110 and 120 v for single-phase input voltages in the range of 80 to 120 v, 45 to 60 cycles. Maximum power rating is 2 kva. Waveform distortion is zero, and recovery time on input voltage surges is 0.08 sec/v.

Dual-Projector Controller

Possibly the most unusual feature of the FEAAFMPS 35mm theater installations, the Dual-Projector Controller partakes of the nature of automation, a subject currently receiving much attention in American industry. Throughout military theater history a basic requirement has been enforced that two projectionists must be on duty at all times during performances. This requirement was fully warranted by safety considerations when nitrocellulose base films were in use, but justification is more difficult since all new features are distributed on safety base stock. Furthermore, qualified projectionists grow more scarce as military manpower shrinks, and inevitable personnel rotation makes it even less likely that servicemen having the necessary training and skill to put on smooth, professional shows will remain long at any particular installation. Therefore, considerable engineering time and development expense have been devoted to centralizing projector controls, and to providing for automatic performance of some of the operating functions which otherwise call for professional skill and good timing sense.

The Dual Projector Controller is the uppermost panel in the Preamplifier integrator cabinet (Figs. 2, 4 and 7), which is always mounted between the two projectors directly under the observation port, thus placing its five control pushbuttons at convenient operating height. Above the pushbuttons are arrow-shaped alternately illuminated indicators to show which projector is set up for starting, and a center pilot lamp to indicate that control relays are powered. The first button on the left starts the arc rectifier of the incoming machine, after which its lamp is struck manually. The next button to the right is depressed when the show is to start, or when the motor start cue of an outgoing reel appears on the screen. It starts the motor of the incoming machine and initiates the automatic changeover cycle via relays and thyratron delay circuits. Other relays complete the cycle, after an appropriate interval for film runout, by shutting off the motor and arc rectifier circuits of the outgoing machine. During the cycle, necessary conditions for changeover in the opposite direction are established.

The center pushbutton marked "Changeover" interrupts the thyratron timing action and reverses the present direction of the controller whenever desirable, for example when there is need to switch back and forth rapidly between machines to check light balance. This button and the two "Stop" buttons on the right are provided with metal guard rims to prevent accidental operation, since they are not normally used.

The "Selector Stop" button to the right of the "Changeover" button inhibits the changeover cycle and preserves status quo in the event of false starts of the incoming machine. The "Master Stop" button on the extreme right breaks all relay holding circuits, thus providing immediate cutoff of all operating functions for emergency stops.

An interior view of the Controller is shown in Fig. 7. Sequential transfer of operating function is effected by a multipoint, six-level rotary switch located below the octagonal cover on the right. Alternate contacts on each level are wired in parallel so that in effect it becomes a 6-pole, double-throw magnetically operated stepping switch shown schematically in Fig. 8. Contact wipers are advanced by spring action when the operating coil is de-energized, thus accomplishing transfer after the actual changeover has been made. This switch was chosen because of its ready local availability and because of inherent delay in its actuation mechanism. It operates on 48-v d-c provided by the bridge-type selenium rectifier occupying the center, rear portion of the chassis. Timing chain, cutoff, and changeover relays also operate from this supply, as do the selfholding power relays for arc rectifier and motor circuits. The relays occupy the lefthand portion of the chassis, along with the two miniature, shield grid thyratons which control their operation.

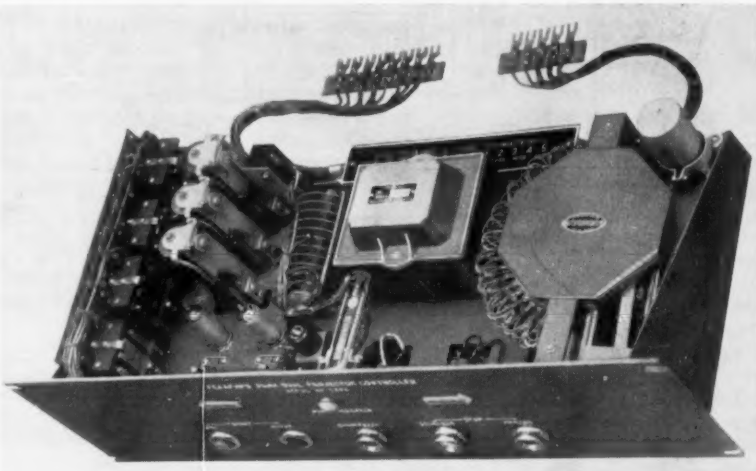

Fig. 7. Chassis layout of latest Dual Projector Controller. Note protective rim guards over "Changeover," "Selector Stop" and "Master Stop" buttons.

Referring to the schematic diagram, Fig. 8, which shows the sequence switch in position for starting the LH, or #1 machine, operation of the "Arc Start" button pulls up relay RL-5, which locks in via its holding contacts. The motor relay, RL-6, similarly locks in when the "Motor Start" button is depressed. Simultaneously this button applies power to the timing chain start relay, RL-2, which locks in via its holding contacts,

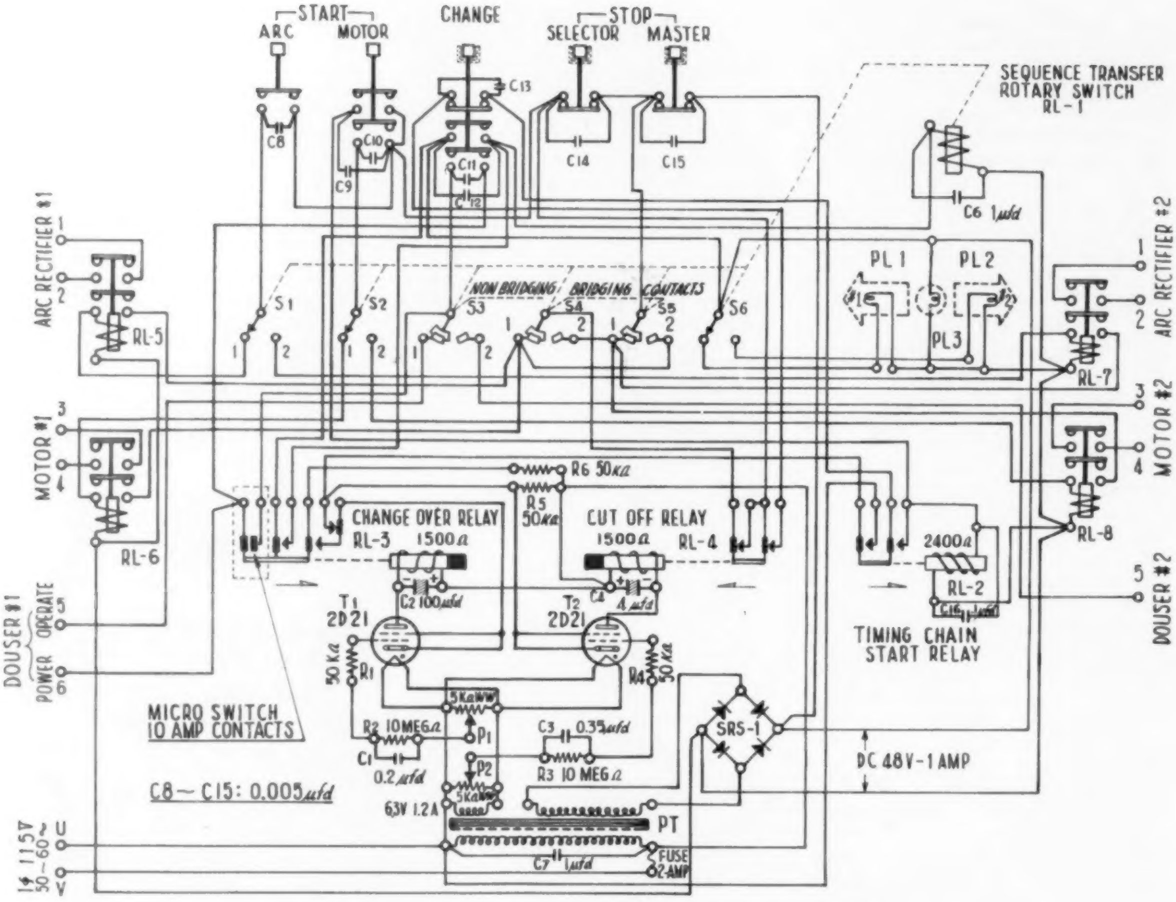

Fig. 8. Circuit schematic of semiautomatic Dual Projector Controller.

and completes the power circuits to the two thyratrons, T-1 and T-2. Each is provided with a control grid RC network and adjustable bias to control the firing delay time. When T-1 fires, its plate circuit relay RL-3 operates an associated microswitch applying power to the machine dousers, opening #1 and closing #2. Delay time initially is adjusted to suit the motor starting time and corresponding standard film threading. The operating coil of RL-3 is shunted by the considerable capacity of 100-μf to afford very slow release and thus adequate contact dwell for positive operation of the dousers. RL-3 also energizes the stepping magnet of rotary sequence switch, RL-1, and extinguishes T-1 by breaking its supply circuit. When RL-3 releases, the sequence switch advances one step, setting up circuitry for the next changeover in the opposite direction. Subsequently thyratron T-2 fires, being adjusted for about 13-sec delay, and its plate circuit relay RL-4 breaks power to the holding coils of the arc and motor relays of the outgoing machine, and of the timing chain start relay, RL-2. The latter relay breaks the power supply to T-2, thus extinguishing it to place the system in readiness for the next cycle. Functioning of the "Changeover," "Selector Stop" and "Master Stop" pushbuttons in manual overcall of the automatic operations is self-evident from the diagram. Arc rectifier and motor relay external circuits contain the usual switches in parallel for manual or emergency operation.

While it would be simple enough to have the controller also effect the sound changeover, experience has shown that in changeovers between different film subjects, dissimilar sound and picture timing is frequently desirable. Also, one of the best emergency features of the preamplifier-integrator assembly may require at times the operation of the preamplifier "Emergency" switch, rather than the normal "Fader" switch, for sound changeover.

Field experience so far with the Controller bears out that all possible operating requirements and contingencies have been covered in its design, and that a single military projectionist can put on shows rivaling in smoothness and overall quality those customarily encountered in the better stateside commercial operations.

Acknowledgments

Credit is due and is extended to many representatives of American and Japanese equipment firms, too numerous for individual mention, who supplied advice and cooperation during the modernization program, planned and coordinated by the author. Specific credits are extended, however, to Dr. K. Takayanagi and Messrs. Hayashi and Hirao of the Victor Co. of Japan, Ltd., Engineering Dept. for their tireless and worthy efforts in producing the Integrators under considerable time pressure; to the brothers Chuji and Tadayoshi Sakai of Ko-on Denpa Co., Ltd., for accurate interpretation of design concept and production of the Controller; and to Ross H. Snyder of Ampex Corp. for outstanding service. Procurement assistance rendered by the parental Army and Air Force Motion Picture Service in the states likewise deserves espcial mention. Finally, the able and constructive contributions of the author's technical associates in his own organization, and firm and unstinting support of its Director and of those military authorities charged with supervision of its mission and policies, are most gratefully acknowledged.

The Testing of Plastics for Use in Contact With Photographic Processing Solutions

By BERNARD A. HUTCHINS

This report outlines the considerations involved in the design and interpretation of experiments to evaluate plastic materials for use in contact with photographic processing solutions. Some of these considerations are: selection of plastic surface-area-to-volume ratio, preparation of the plastic sample for testing, designing the photographic evaluation, and interpreting the results in a nonstatistical manner. Information is also included summarizing the results of similar tests which have been run.

THE USE of stainless steel as a material of construction for photographic processing equipment has been quite generally accepted. Nonetheless, it has a tendency to be attacked by certain bleaches, is difficult to fabricate, is not flexible, and is expensive. There has been considerable interest in the use of plastics as substitutes for tanks and piping in those locations where stainless steel is inadequate as well as where it is satisfactory except for cost. In contrast to what occurs with some metals, the corrosion characteristics at the air-liquid-plastic interface were found to be no different from those at the liquid-plastic interface.

The danger of producing a detrimental photographic effect by using an untested plastic material is not very great if the plastic is preseasoned in the solution to which it will be exposed and if it will be used at a low ratio of surface area to volume, or if the system in which the plastic is incorporated contains solutions that are continuously replenished. Even if these conditions can be met, it still may be uneconomic to use an untested plastic. A general scheme for testing such plastic materials is given in this paper.

Design of the Test

Certain properties of plastic materials in relation to photographic processing solutions must be considered in designing the test. (1) The surfaces of many plastics become contaminated by finishing operations or handling. Such materials can be made useful by "seasoning." Materials of this type can be determined by successively immersing the sample in fresh portions of processing solution and examining the solution photographically and chemically, until no further contamination is observed. (2) Other materials may continue to progressively contaminate a single batch or successive fresh batches of solution with continued exposure. Such effects are usually caused by the slow diffusion of plasticizer from the plastic or by decomposition of the plastic by continued contact with the processing solution. In this case, it may be advantageous to use the material because of its desirable properties and in spite of the contamination that results. It is necessary then to determine the degree of contamination that can be tolerated without producing significant photographic effects. A processing solution is treated with an excessive amount of plastic and then diluted with fresh solution. Photographic tests will then indicate whether a replenishment system will eliminate the contamination.

If one has at his disposal sensitometric exposures, densitometry, and a processing machine in which he can test several variations at one time, and if he knows the inherent variability of emulsion plus process plus machine, then the problem of running and interpreting the photographic test is not very great. However, since these machines are not generally available, and also since they do not represent the system to be evaluated, some improvisation is necessary. The basic design of the experiment described below is identical whether carried out on sensitometric equipment with a high degree of control or on available simple equipment. Interpretation must be based on the amount of control in the experiment. The design presented below permits the detection of an unsatisfactory material, although this design may be incapable of efficiently comparing fundamentally good or borderline materials.

It is desirable to run the test under slightly more severe conditions than the material will encounter in actual practice. However, exaggerations should be made only in conditions such as time, area-to-volume ratio, and perhaps agitation. It would be misleading if tests were run in which temperatures, pH, or other factors normally influencing chemical reaction rates were varied.

The specific example to be considered is the proposed use of polyethylene sheet as a floating cover on a processing tank for storing an Eastman Color Negative Color Developer. The area of the cover to be exposed to the developer in a 2000-liter tank is approximately 8000 sq cm, or 4 sq cm per liter (lower side only). The time of exposure could be overnight or over a weekend. This material is homogeneous and may be cut as desired.

Preparation of the Contaminated and Standard Color Developers

Three liters of fresh Eastman Color Negative Color Developer (tank formula) should be prepared or 3 liters of seasoned solution should be used to fill completely two 1-liter glass-stoppered bottles. Polyethylene sheet in the amount of 4 sq cm is inserted into one of the bottles. This plastic-area to developer-volume ratio is now about twice (100% excess considering both sides) what would be encountered when the polyethylene is used as a floating cover. Both bottles should be stored under identical conditions for two to three days.

Chemical Testing

At the end of the contaminating period it may be desirable to analyze both bottles of color developer to see what specific chemical concentrations have changed owing to the contamination. If an ultraviolet spectrophotometer is available, a complete absorbance curve of both developers is sometimes revealing. A significant difference between spectrophotometric curves is not a primary basis for rejecting a material but it may explain an unsatisfactory photographic effect.

Photographic Testing

Photographic testing can be carried out in 1-liter graduated cylinders immersed in a 70 F constant temperature bath. Fresh tank formulas of Prebath, First Fixing Bath, Bleach, Second Fix, Stabilizing Bath and Wetting Agent can be prepared, or solutions from seasoned tanks may be removed from an operating processing machine. Two test exposure strips are processed simultaneously through the Prewash, separated for the contaminated and standard Color Developers, and processed together for the rest of the process. It may be possible in some laboratories to carry out all the processing operations except development by dipping the test exposure strips in the large machine tanks. The above test, using two more test exposure strips, should be repeated.

Interpretation of the Photographic Test

Interpretation of the photographic test consists of deciding whether or not a real photographic difference exists between test-exposure strips processed in

Presented on October 5, 1955, at the Society's Convention at Lake Placid, N.Y., by Bernard A. Hutchins, Color Technology Div., Eastman Kodak Co., Rochester 4, N.Y.
(This paper was received on January 9, 1956.)

Table I. Solutions in Which Rigid Materials Are Satisfactory at Ratios of 75 Sq Cm per Liter or Less.

Type and Name of Material	Process for ECN 5248	Process for ECP 5382
Polyvinyl chloride:		
Ampcoflex	Bleach	Bleach
Arnold & Richter Plastic	Developer	Developer
Atlas Pee Vee Cee	Bleach	Bleach
Boltaron	Developer	Developer
Koroseal	Developer	Developer
Polystyrene:		
Arnold & Richter Styron 475	Developer	Developer
Fico-Fiberglas Impregnated	Developer Bleach	Developer Bleach
Polystyrene-Fiberglas Impregnated	Developer Bleach	Developer Bleach
Copolymers:		
Uscolate (Polystyrene and Buna N or S)	No Test	Prewash Developer Fix, Bleach
Saran Pipe (Copolymer of Vinylidene Chloride and Vinyl Chloride)	Developer Bleach	Developer Bleach
Saran Fitting	Developer Bleach	Developer Bleach
Phenolic Resins:		
Bakelite	Developer Bleach	Developer Bleach
Synthane (Laminated)	Developer	Developer
Phenoline 300 (Paint)	Developer	No test
Polytetrafluorethylene:		
Chemiseal	Prewash Developer Fix, Bleach	Prewash Developer Fix, Bleach
Clear Cast Alkyl Diglycol Carbonate:		
CR-39	Developer	No test
Epoxy:		
Epoxy Hysol	Developer Bleach	Developer Bleach
Araldite	Developer	Developer
Acrylic:		
Lucite	Developer Bleach	Developer Bleach
Plexiglas	Developer Bleach	Developer Bleach
Polyamide:		
Nylon	Developer Bleach	Developer Bleach
Cellulose Acetate Butyrate:		
Tenite II (96 hours' preseasoning recommended)	Prewash Developer Fix, Bleach	Prewash Developer Fix, Bleach

Table II. Solutions in Which Flexible Materials Are Satisfactory at Ratios of 75 Sq Cm per Liter or Less.

Type and Name of Material	Process for ECN 5248	Process for ECP 5382
Rubbers and Synthetic Rubbers:		
Goodyear Wingfoot Hose	Developer Bleach	Developer Bleach
Gum Rubber, ½-in. Tubing	Developer	No test
Rubber Valves	Developer Bleach	Developer Bleach
Neoprene N7 Valve Diaphragms	Prewash Developer Bleach, Fix	Prewash Developer Bleach, Fix
Radiator Hose	Developer Bleach	Developer Bleach
Polyvinyl Chloride:		
Koroseal (Plasticized) Tubing	Developer	Developer
Koroseal Sheeting	Prewash Developer Fix, Bleach	Prewash Developer Fix, Bleach
Polyethylene:		
Semi-Rigid Pipe	Developer Bleach	No test
Copolymers:		
Saran Tubing	Developer Bleach	Developer Bleach
Modified Vinyl Resin:		
Tygon Tubing	Developer	Developer

the standard and in the contaminated color developers. A real difference is deemed to exist between the developers when the pictures and strips show differences greater than normal process variability.

(1) If a densitometer is available, the test strips should be measured as a basis for making comparisons. If the densitometric differences between the two strips through the contaminated developer are small and the differences between the two standard test-exposure strips are small, the significance of the difference between the two sets of strips can be appraised. The standard strips should be close to standard for most reliable conclusions.

(2) If no densitometer is available, the four test-exposure strips should be coded and submitted to several qualified individuals for examination. Each individual should try to select two as being different from the other two. If the individuals cannot make this selection or cannot agree, the variability in the process is too great to be conclusive, or there is no significant photographic effect.

Action

If a large photographic effect is observed, one would do well to consider a substitute material.

If the effect is small, it may be disregarded in view of the other benefits of floating covers and of the fact that the test was made under more severe conditions than will be encountered in practice.

If no effect is observed, proceed to cut a cover for the storage tank.

Restrictions

In common with other laboratory data some risk is involved in extrapolating from these tests to production conditions because:

(1) The compositions of proprietary products are so subject to change that extrapolation of the data to future compositions is not justified.

(2) The identity and amount of plasticizers present in the particular formulation may have more to do with its photographic effect than the main component itself.

(3) Laboratory tests are of limited duration and as such are incapable of predicting long-term physical and mechanical changes.

(4) The surface-area-to-volume ratios are usually selected to fit specific needs. It is reasonable to conclude that lower ratios of plastic surface-area to solution-volume would be less harmful whereas higher ratios might make a satisfactory material unsatisfactory.

(5) Some of the materials classified as unsatisfactory might conceivably become satisfactory by extended contact, i.e., seasoning, with the appropriate processing solutions used in a continuous processing machine. The reverse may also be true.

Tables I and II include the results of tests similar to the test described above. Several rigid and flexible plastic materials have been found to be satisfactory in the Eastman Color Negative and Print Film solutions listed.

Discussion

J. I. Crabtree (*Eastman Kodak Co.*): Have you found any plastic which does not have a tendency to become stained with dye solutions? I have particularly in mind of course the use of plastics for construction of trays and small tanks. I have not to date come across any which do not stain badly and become scratched very easily. The scratches in turn accumulate dirt so that it is difficult to keep a plastic material clean.

Mr. Hutchins: We have not found a white, or near-white material that does not stain.

Mr. Crabtree: What is the effect of alcohol solutions on, say, Tygon, or have you not investigated the effect of organic solvents on the plastics?

Mr. Hutchins: We have not made such tests.

news and reports

40-Year Society Index

An Index for the Society's *Transactions* and *Journal* for 1916–1955 is being prepared.

It will contain the usual Author Index and a Subject Index similar to those in each volume index and in the Society's past cumulative indexes—1916–29; 1930–35; 1936–45; and 1946–50.

Choosing the Subject headings for this type of index is most important; therefore the Editor will welcome advice and suggestions in order to avoid errors or omissions such as have occurred in the past.

Also, please call the Editor's attention to errors or omissions in entries in any of the past indexes. Although copy for the 40-Year Index will be held against the *Journal* pages, the copy will be initiated from the past indexes.

Plans now are for the format to conform to the present $8\frac{1}{4} \times 11\frac{1}{4}$ in. size of the *Journal* rather than the former 6×9 in. size.

Distribution plans are for special prepublication order and price arrangements for members at time of publication and for active sales to libraries and subscribers.—*Ed.*

How to Get a Copy of "Old" Articles in the Journal

First, the Society has in stock back issues of almost all the months and years of the *Journal* and the *Transactions*. If you do not have a copy, send for "List of SMPTE Publications" which lists the few not available. Back issues are available to members at 10% discount on $2.00 for one-part issues and $2.50 for special two-part numbers.

Second, brief articles may be purchased a little more economically, compared with buying back-issues, in the form of photostats from a library. Also, articles from out-of-stock issues can be gotten as photo copies. Many libraries offer this service which has many alternatives such as between dull or glossy finish; microfilms; minimum and maximum charges; prepayment, deposit or invoicing procedures. Detailed charges and suggestions should be available from your local library. The information and services are interesting as made available to anyone inquiring of: (1) Engineering Societies Library, 29 West 39th St., New York 18; and (2) Photographic Service Div., The New York Public Library, 5th Ave. and 42 St., New York 18.

Third, microfilms are available to members of the Society and subscribers to the *Journal* upon application to University Microfilms, 313 N. First St., Ann Arbor, Mich. University Microfilms are made by years (2 volumes per year) beginning with volume 54 (1950) at costs ranging from $3.45 per year, depending on the size of the volumes included in the year. Volume 64, which is the first annual volume, costs $2.25.

Third International Symposium on High-Speed Photography

A note from the man in the U.S.A. who has all the information:

The Third International Congress on High-Speed Photography will be held in London, September 10th to 15th, 1956. The Congress is being sponsored by the Department of Scientific and Industrial Research of the Government of Great Britain.

The preliminary program has just been received and it promises to be the finest yet to be presented. Approximately 80 papers will be presented by scientists from all over the world. Among them will be Schardin, Fayolle, Naslin, Courtney-Pratt and Chesterman.

At the Second Congress it was decided the proposed date for the Third International Congress should tie in with Photokina (an international exposition of photographic equipment) which is held in Cologne. Consequently, Photokina will follow the Third International Congress two weeks later, and an air tour has been arranged by Pan American World Airways.

Departure is scheduled from Idlewild Airport, New York, September 7th at 5:30 P.M. on flight No. 70. We will arrive in London, Saturday, the following morning, at 9:20 A.M. The tour will be a month in all consisting of one week in London, one week in Paris, several days in Geneva and a week in Cologne. Excellent accommodations will be provided. Tours to Government installations in Paris, Geneva and Cologne are being arranged for the men. For the ladies, a special series of tours are being lined up.

This will be a trip that you will never forget and it is hoped that you will join our party on the SUPER 7 Non-Stop to London. The complete itinerary, prepared by Pan American, will be sent anyone interested.

JOHN H. WADDELL
88-06 Van Wyck Expressway
Jamaica 1, N.Y.

Education, Industry News

"Photokina," an International Photo and Cine Exhibition, will be held in Cologne, Sept. 29–Oct. 7, 1956. On exhibit will be cameras, plates, chemicals, accessories, photo literature, photographic papers, reproducing apparatus, light sources, laboratory requisites, projectors, enlargers, stands, optics and films. American representative for Photokina is the German-American Trade Promotion Office, Suite 6900, 350 Fifth Ave., New York 1.

A second International Photographic Exposition is being planned for March 22–31, 1957, in Washington, D.C. The first such meeting was held in Paris in May 1955. Cancelling their own regular annual trade meetings, to participate are the following associations: National Assn. of Photographic Manufacturers, Master Photo Dealers' & Finishers' Assn., Photographers Assn. of America, National Assn. of Press Photographers, and Photographic Society of America. In the National Guard Armory in Washington, 135,000 sq ft of exhibitions will be open to the trade and professional photographic people in the daytime and to consumers in the evening.

The National Association of TV Film Directors has released the results of an initial survey on nation-wide film room practices. William L. Cooper, Jr., Film

Director of WJAR-TV, Providence, R.I., founder of the Association and now Chairman of the Technical Standards Committee which conducted the survey, has released the preliminary findings.

Through the District Chairmen of the organization, every TV station in the country was reached. Ten questions were asked, and answers received indicated the following:

The one detail that gives the most trouble in film room operations:

Films that arrive late	33%
Repairing film received in damaged condition from the distributors, due to improper inspection by them	33%
Editing features to fit time slots	10%
Blocking out old cues	10%
Syndicated shows not marked for commercial inserts	8%
Dirty film; lack of time to preview; lack of time to keep required records; last-minute changes; requests to tranship film without provision of shipping cases; not knowing what to do with spots after schedule is completed	Remainder

The one detail that gives the least trouble in film room operations:

Preparation of syndicated programs	12%
Shipping	15%
No answer	42%
Inspecting; splicing; timing; cleaning; scheduling; screening	Remainder

Cuing

5 & 1 Sec	38%
Audio and visual cues only	14%
9 & 7 & 2; 10 & 5 & 1; 3 & 1	5%
Other methods	Remainder

Have you abolished hand-type punch cuers yet?

Yes	91%
No	9%

Society numbered leader on all film:

Yes	51%
No	33%
Sometimes	19%

Records for transshipment of films:

Card file	49%
Shipping ledger	40%
Notices posted on film room wall	5%
Daily shipping report	3%
Different colored cards that travel with films; cases for transshipment put on a special shelf; advance typed labels; permanent shipping schedule; express company's own waybill book	Remainder

Ideas and suggestions of problems needing discussion:

Standard cue	40%
Better checking for print quality by distributor	22%
Better system for transshipments	12%
How to clean film properly	8%
Standard method of shipping charges	5%
New equipment better suited for TV use	3%
Standard type of leader supplied on all film	3%
Replacing cuts in wrong sequence; standardization of spot commercial markings; negligence of distributor on confirmations; not receiving enough commercial spots during a heavy campaign; others	Remainder

A Report from the Association of Cinema Laboratories

By NEAL KEEHN

Directors and Officers elected. . . . Membership growing. . . . Work progresses on nonmenclature. . . . Plan to set up a central office.

With its January 26, 1956, annual meeting in New York, the Association of Cinema Laboratories, Inc., began its third year as a formal organization.

The Membership Chairman, Kern Moyse, announced 43 active members, including 5 in the West, 8 in Canada, 13 in the New York area, 3 in the Washington area, 3 in the South and Southwest and 10 in the Midwest. He also reported a number of inquiries regarding membership from other countries.

An amendment to the bylaws to cover associate memberships was read and explained by Mr. Moyse. He stated that several non-laboratory firms had expressed an interest in helping with Association work, and that the Board of Directors had commissioned him to prepare the amendment necessary for their membership. By unanimous vote, the amendment was adopted. It establishes associate memberships with all rights and duties except the right to vote.

New directors elected were Byron Roudabush of Byron, Inc., and Neal Keehn, The Calvin Company, for two-year terms; Don M. Alexander of Alexander Film Co., James A. Barker of Capital Film Laboratories, Louis Feldman of Du Art Films Laboratories, Russell Holslag of Precision Film Laboratories, and Kern Moyse of Peerless Film Processing Corp., for one-year terms. Directors serving through 1956 are Geo. W. Colburn of Geo. W. Colburn Laboratory, and Saul Jeffee of Movielab Film Laboratories.

The election of directors was the last order of business of the annual meeting and was followed by a Board meeting. Reelected by unanimous vote of the directors were Neal Keehn, Vice-President of The Calvin Company, as President; Russell Holslag, General Manager of Precision Film Laboratories, as Vice-President; Geo. W. Colburn, President of Geo. W. Colburn Laboratory, as Treasurer; and Byron Roudabush, President of Byron, Inc., as Secretary. These officers consented to serve one more year on the understanding that none of them be available for reelection for the same office the next year, and that an attempt would be made to establish a paid secretary sometime during the coming year, to organize more efficiently the growing volume of work involved in Association activities.

The Secretary reported that the Association's recommendations for the preparation of 16mm A&B rolls, marking of the 16mm workprint for optical effects, and the preparation of 16mm leaders had been widely reproduced in various trade publications, and that there had been a heavy demand for the Association's own explanatory sheets. The Treasurer reported a cash balance of over $2,000, with no large billings due. Russell Holslag, Chairman of the Nomenclature Committee, reported on a preliminary listing of 20 laboratory terms which had been developed by his committee and was to be submitted to the entire membership for consideration and comment, leading to eventual acceptance for common usage between laboratory and producer.

Guest speakers included William H. Metzger of Ansco, Victor M. Salter of Du Pont Photo Products, Jack Squires of Williard Pictures Inc., and E. M. Stifle of Eastman Kodak Co.

Mr. Squires spoke on the subject of the producers' problems in dealing with the laboratory. The three film manufacturers' representatives outlined new film stocks recently introduced or expected.

The Association has as its primary purpose the development of standard laboratory methods and practices. For membership information, write Mr. Kern Moyse, Peerless Film Processing Corp., 165 W. 46 St., New York 36. The roster of the Association's members now is as follows:

Alexander Film Co., Colorado Springs, Colo.
Associated Screen News. Ltd., Montreal
Atlas Film Corp., Oak Park, Ill.
Beeland-King Film Productions, Atlanta
Byron, Inc., Washington, D.C.
S. W. Caldwell, Ltd., Toronto
The Calvin Company, Kansas City, Mo.
Capital Film Labs., Inc., Washington, D.C.
Circle Film Laboratories, Inc., New York
Geo. W. Colburn Laboratory, Inc., Chicago
Colorfilm, Inc., Mamaroneck, N.Y.
Consolidated Film Industries, Hollywood
Color Service Company, New York
Coronet Instructional Films, Chicago
Crawley Films, Ltd., Ottawa
Du Art Film Laboratories, Inc., New York
Film Associates, Inc., Dayton, Ohio
Fischer Photographic Labs., Chicago
General Film Laboratories Corp., Hollywood
General Film Laboratory, Detroit
Guffanti Film Labs., Inc., New York
Houston Color Film Laboratories, Inc., Burbank, Calif.
Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa
Kling Photo Corporation, New York
Lakeside Laboratory, Gary, Indiana
Mecca Film Laboratories, Inc., New York
Movielab Film Laboratories, New York
National Cine Labs, Hyattsville, Md.
National Film Board of Canada, Ottawa
Northern Motion Picture Laboratories, Ltd., Toronto
W. A. Palmer Films, Inc., San Francisco
Peerless Film Processing Corp., New York
Precision Film Labs, Inc., New York
Quality Film Laboratories Co., New York
Reid H. Ray Film Industries, Inc., St. Paul
S.O.S. Cinema Supply Corp., New York
Shelly Films, Ltd., Toronto
Southeastern Film Processing Co., Columbia, S.C.
Southwest Film Laboratory, Dallas, Texas
Strickland Film Co., Atlanta, Ga.
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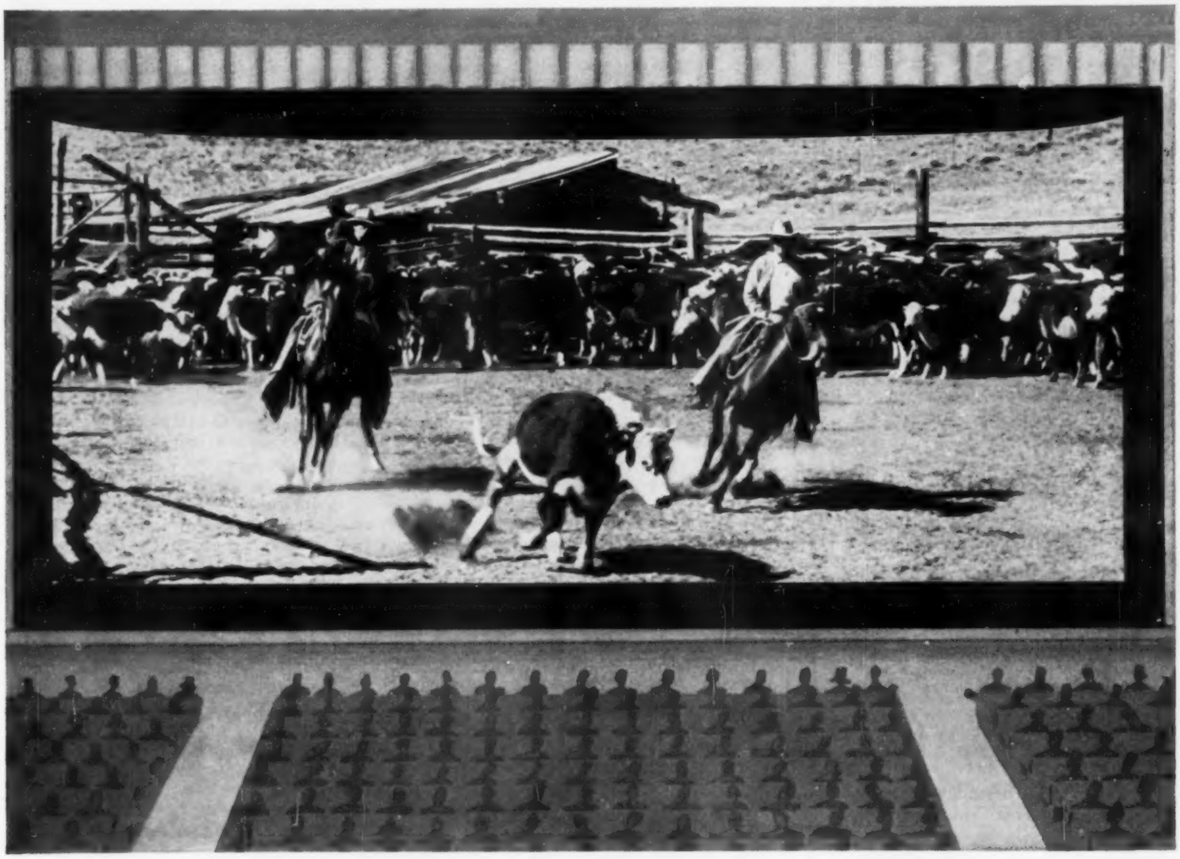

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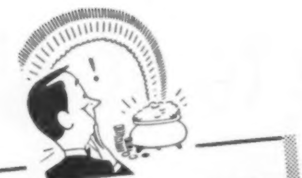

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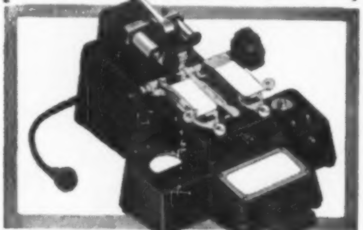

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section reports

The **Northwestern Section** met on January 31 in the Demonstration Room of Ampex Corp., Redwood City, Calif. Twenty-two members attended. John M. Leslie, Jr., Chief Audio Engineer of Ampex, spoke on "High-Speed Duplication of Magnetic Tape Recordings." The presentation included a demonstration of the comparison of a sixth-generation duplicate with an original recording, and a demonstration of stereo reproduction.

Enthusiastic interest was shown in the demonstrations and in the stereo reproductions which Mr. Leslie ably discussed.

The February 16 meeting of this Section was held at the Stanford Research Institute, Menlo Park, Calif., with 20 members present.

The program was provided by William E. Evans, Howard C. Borden and Ralph Heintz, all of the Television Engineering Dept., Stanford Research Institute. The topic, "Radar Photography," was presented in the form of descriptions and demonstrations of equipment developed for the Air Force training program. Both direct 16mm and 35mm motion-picture photography of PPI as well as the recording of video signals for later reproduction on a PPI in a classroom was described.

An attendance of only 20 for so interesting a meeting as this seems on the surface to be low. Actually, membership in this particular field is small, and the military aspect necessarily keeps it so.—*R. A. Isberg*, Secretary-Treasurer, Consulting Television Engineer, 2001 Barbara Dr., Palo Alto, Calif.

The Atlantic Coast Section met on February 14 at the Carl Fischer Concert Hall, New York. Attendance was approximately 175 persons, most of whom are members. Dr. Philip Nolan, Chief Physicist of Farrand Optical Co., was the speaker. His talk was on the general subject of the fundamental principles of optics as related to motion-picture equipment. He described the requirements of field uniformity and intensity and the problem of light losses in optical systems. His presentation was followed by an interesting question-and-answer period.—*Victor M. Salter*, Secretary-Treasurer, c/o E. I. du Pont de Nemours & Co., Inc., 248 W. 18 St., New York.

The Western New York Section met on February 16 at the Dryden Theater, Rochester, N.Y., following a speakers' dinner and managers' meeting at the Rochester Club.

Leonard Satz, Secretary-Treasurer of Raytone Screen Corp., Brooklyn, discussed "Problems of Large-Screen Theater Presentation." He pointed out that in spreading pictures over the large screens now being used, the light output of the projector is frequently inadequate.

Attributes of the matte white screen and of several types of high-gain screens were discussed and demonstrated. It was pointed out that the matte white screen provides the most even picture brightness from all viewing angles. However, with wide-screen pictures this brightness is frequently uniformly inadequate. Described were various types of high-gain screens which provide a much brighter picture when viewed from the center of the theater. The brightness of these screens, however, falls off very rapidly as the viewing angle increases. One type of such material was shown which provides moderate gain in brightness while maintaining a much more uniform reflectance over a very wide angle.

Problems in screen construction, shape, maintenance and orientation were discussed. Some of the characteristics of beaded and lenticulated screens were also described.

A number of people who work primarily with film manufacturing found this discussion took them into a field with which they have had little experience. Those in the audience more closely associated with the theaters pointed out that this was one of the relatively few occasions when their interests and problems were presented in the SMPTE programs. It was pointed out that meetings such as this could do much in advancing the art by presenting new technical information and developments to exhibitors and others directly concerned with theater presentations. Some of the theater people present recommended that future papers of this type should be more widely publicized in order to reach others in their field.—*George T. Negus*, Secretary-Treasurer, c/o Eastman Kodak Co., Kodak Park Works, Bldg. 31, Color Technology Div., Rochester 4, N.Y.

The Central Section met on February 20 at the Western Society of Engineers, Chicago, with 95 people attending. A panel discussed the use of prestriped magnetic sound coatings in sound motion pictures. E. W. D'Arcy, E.D.L. Company, served as moderator and sitting with him were: R. S. Dubbe, Minnesota Mining & Manufacturing Co.; Price Fish, Columbia Broadcasting System; John Powers, Bell & Howell Co.; Jerry Sevenberg, Geo. W. Colburn Laboratories; and Spencer Allen, WGN-TV.

A single-system magnetic recording was demonstrated, and the panel discussed various problems in the application of prestriped magnetic film. Messrs. Dubbe and Sevenberg discussed the magnetic coating of unexposed film, while John Powers covered equipment now available and discussed standardization with reference to single-system cameras and projectors. Mr. Fish reviewed operations in the TV station with particular reference to prestriped magnetic film, and Mr. Allen pointed out areas of potential use in the TV news field, with some of the problems yet to be solved. Moderator D'Arcy, because of his background in the field of magnetic recording, supplemented the material presented with pertinent remarks, and an excellent discussion followed.

Henry Ushijima, of the Geo. W. Colburn Laboratories, showed a series of excellent slides and a reel of motion pictures which

he made during a tour of duty in Central and South America. He had concentrated his camera particularly on architecture, transportation and people.—*Howard H. Brauer*, Secretary-Treasurer, 7326 Ridge Ave., Chicago 45.

The Atlantic Coast Section met on March 7 at the Belmont Plaza Hotel, New York, with about 125 people present. John W. Wentworth, Manager of the Television Terminal Equipment Engineering Group, Radio Corp. of America, Camden, N.J., explained the theory of compatible color television in simple and large nonmathematical terms. Film slides of system block diagrams showed the transition from familiar principles of monochrome television to the more complex techniques of color television. A simplified technical extract of the standards for compatible color television, as approved by the Federal Communications Commission, was presented.—*Victor M. Salter*, Secretary-Treasurer, c/o E. I. du Pont de Nemours & Co., 248 W. 18 St., New York.

The Western New York Section met on March 15 in the Color Room of Eastman House, Rochester, N.Y., with 93 people present. Barry O. Gordon, Technical Director of Graphic Films, Ltd., Toronto, spoke on "The Animated Film."

Mr. Gordon described the animation stand and camera and explained methods used to prepare artwork and manipulate it on the stand. He outlined a variety of techniques for producing desired effects without having the artist prepare a complete new picture for each frame in the film. The audience felt that Mr. Gordon had very effectively let them in on the inside secrets and tricks of the art of animation.—*George T. Negus*, Secretary-Treasurer, c/o Eastman Kodak Co., Kodak Park Works, Bldg. 31, Color Technology Div., Rochester 4, N.Y.

The Pacific Coast Section met on March 20 at the Kling Studios, Hollywood, with 400 members present. A description of the techniques and facilities comprising the Todd A-O Process, inspection of the Todd A-O re-recording and projection equipment, and screening of picture and sound selections from recent productions made up the program.

Because of limited accommodations, two separate sessions of 200 members each were held. Facilities of the Kling Studios were open for inspection before the first and after the second session.

S. A. Sanford, General Manager of Todd A-O, Pacific Division, described production aspects of the process, and showed scenes from the new Michael Todd production, *Around the World in Eighty Days*.

Ed W. Templin, Westrex Corp., described the Todd A-O sound recording facilities.

Fred Hynes, Director of Sound Recording for Todd A-O, described recording, rerecording and electrical printing for the process. Significant techniques and practices developed and utilized in providing six-channel stereophonic sound for the Todd A-O Process were interesting and impressive. Picture and sound demonstrations from the Rogers and Hammerstein production of *Oklahoma!* were enthusiastically received by members at both sessions.

Carlos Elmer of the Naval Ordnance Test Station at China Lake, Calif., announced that SMPTE members and their guests will be invited to the Station on Armed Forces Day, May 19, for a complete tour of the facilities. Details will go to members before that date.—*John W. DuVall*, Secretary-Treasurer, c/o E. I. du Pont de Nemours & Co., 7051 Santa Monica Blvd., Hollywood 38.

The Northwestern Section met on March 29 at the Coronet Theater in San Francisco, where Hal Hummel of the Ampex Corp. and Jess Lunsford and Harry Meyer, projectionists for the Coronet Theater, explained the Todd A-O System and conducted a tour of inspection of the booth of the theater. *Oklahoma!* was shown following the meeting.—*R. A. Isberg*, Secretary-Treasurer, Consulting Television Engineer, 2001 Barbara Dr., Palo Alto, Calif.

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The Atlantic Coast Section held its April meeting at the Carl Fischer Concert Hall, 165 West 57th St., New York, on April 4, 1956. About 60 were present to hear the reading and discussion of a paper on the Du Mont Vitascan equipment, entitled "The Vitascan Live Flying-Spot Color Scanner," by Jesse H. Haines and G. Richard Tingley of Du Mont's Circuit Research Laboratories. (A notice on this equipment appeared in the New Products section of the November 1955 *Journal.*) In his presentation, Mr. Haines described the basic principles of the Vitascan system with the aid of appropriate slides. The evolution of the flying-spot principle was traced to the present time and a detailed description of the equipment that has so far been made available commercially was included.

Also included in the talk was discussion of the advantages and limitations of the system. After the formal presentation was concluded, questions were taken from the floor and an interesting question-and-answer period followed.—*Victor M. Salter, Secretary-Treasurer,* 168 Kemp Ave., Fair Haven, N.J.

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books reviewed

Color in Motion Pictures and Television

By Lyne S. Trimble. Published (1954) University of California, Los Angeles, Calif. 270 pp. 80 illustrated cartoons. 8½ × 11 in. Price $6.50.

This textbook has been developed over a period of several years in the presentation of a course for students in the Department of Theater Arts at the University of California at Los Angeles. Although written for nontechnical readers, who are assumed to have some knowledge of black-and-white motion-picture practice, the book is devoted to the technical side of the subject, and contains much detailed information. Unfortunately, this technical detail tends to lack precision and accuracy, as illustrated by the following excerpts (italics are the reviewer's):

"...one such millimicron is *one tenth* of an Angstrom unit." (p. 6); "We are so far away from the sun and the energy is changing at such a small rate, that we can move around quite a bit without a noticeable change in the intensity of sunlight. The energy as we measure it, then, will fall off with a rate which is somewhat *less than is prescribed by the inverse square law.* This deviation becomes noticeable when the distance from the source exceeds about twenty times the diameter of the source." (pp. 34–5); "...a cyan filter will absorb its *complement,* magenta..." (p. 62). The description of flicker photometry on p. 63 is obviously based on a misconception, and the account of color mixture properties of the eye is wrong in some places. Deviations from standard terminology are also encountered. For example, the components of an additive mixture of *three* colors yielding white are consistently referred to as "complementary," whereas in accepted practice this term is applied only in cases where *two* components add to produce white.

The writer appears to be on more familiar ground in discussions of the historical background and development of the various color processes for cinematography, but his conclusions are sometimes debatable.

The body of the book is devoted to color motion pictures, only the last chapter being directly concerned with television.—*Charles H. Evans,* Eastman Kodak Co., 59 Kodak Park, Rochester 4, N.Y.

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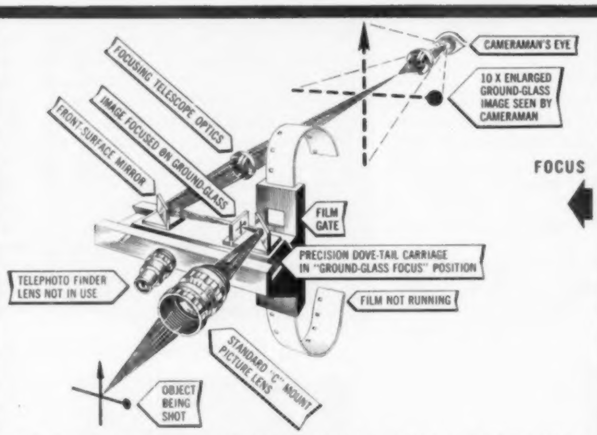

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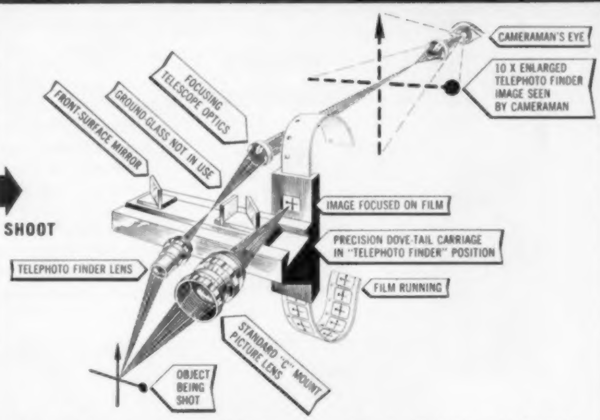

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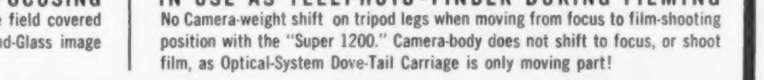

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Color Television Standards

By Donald G. Fink. Published (1955) McGraw-Hill Book Co. 330 W. 42 St., New York 36, 520 pp. Illus. (4 in color) Graphs. 6 × 9 in. Price $8.50.

It was, I suppose, inevitable that to Mr. Fink would fall the task of recording in book form the deliberations of the National Television System Committee, which led to the formulation of the compatible color standards adopted by the Federal Communications Commission.

One of the stalwarts of the television industry, Mr. Fink was, for many years, editor of "Electronics," before joining the Philco Corporation as Director of Research. He served as Vice-Chairman of the NTSC during the period 1950–1952 and was exceedingly active during an earlier period of the industry's history when the NTSC was first formed to develop standards for monochrome television. He subsequently compiled a book based on the findings of the Committee called *Television Standards and Practice*.

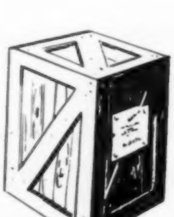
Mr. Fink's new book, *Color Television Standards*, brings home very forcibly the extent and the rapidity of the expansion of the boundaries of the television industry's technical knowledge and its contribution to the science of color. The logical procession of information is covered in 10 chapters and 2 appendices in 520 pages, and includes the following:

The development of color television; the NTSC color television standards; subjective aspects of color; the color video signal; the color synchronizing signal; field tests of compatibility, color performance and networks and transmitters; color films, processes and transmission equipment; and definititions of color television terms and symbols.

The compilation from the records of the NTSC covers essentially all the technical information evolved during the NTSC proceedings. As an example of its completeness, Chapter 4 — "The Color Video Signal," the most important chapter in the book — encompasses over 25% of the total pages.

Mr. Fink's editorial skill has achieved an excellent technical documentation of the factors underlying the choice of the compatible color telecasting standards adopted by the Federal Communications Commission. Because of its source material, this book represents a most authoritative and comprehensive statement on the basic problems of compatible color television engineering and the technical parameters involved in their solution.

The book, *Color Television Standards*, is written for the professional engineer and, as such, merits a high place in every engineering library. It accomplishes several purposes. It is a virtually complete technical record of the work of the NTSC. It is a tremendously important statement of the various considerations underlying the United States color television system, and it is a tribute to the genius and skill of the American television industry and its continuing contribution to the science of communication.—*G. R. Tingley*, Manager—Color Dept., Allen B. Du Mont Laboratories, Inc., Circuit Research Laboratories, 2 Main Ave., Passaic, N.J.



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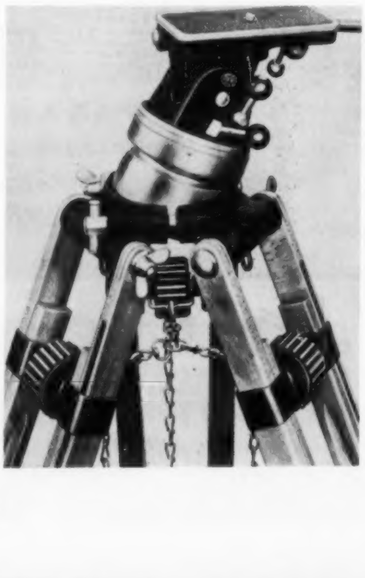

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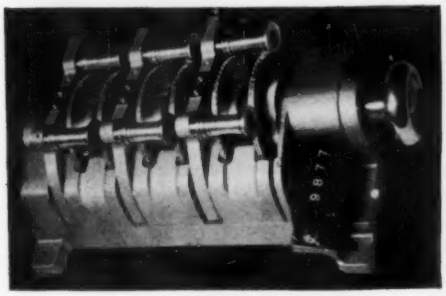

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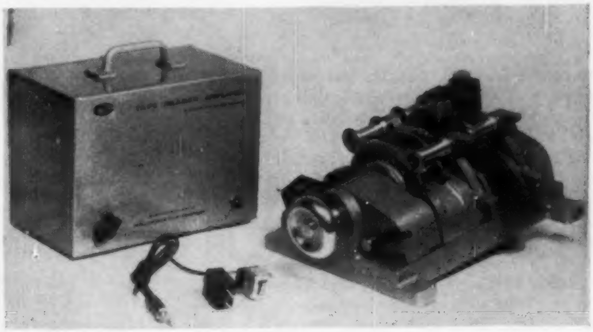

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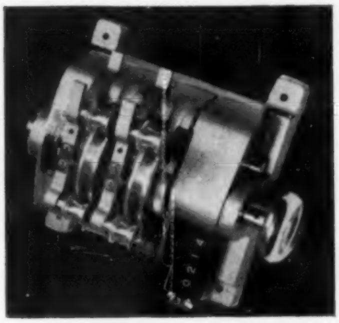

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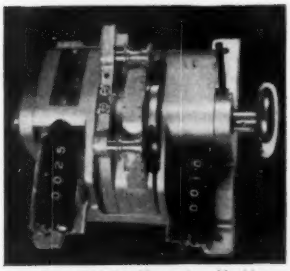

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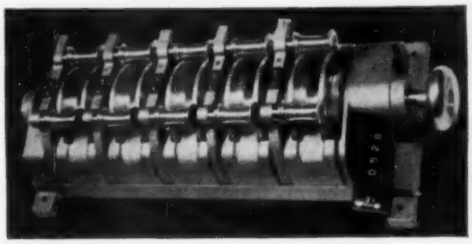

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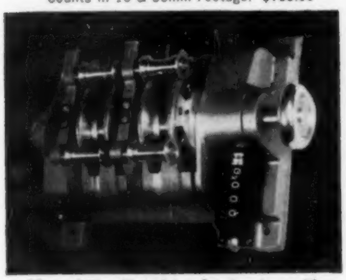

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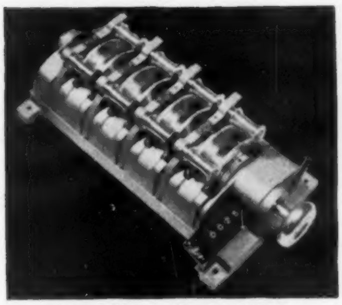

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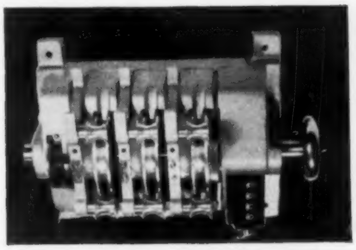

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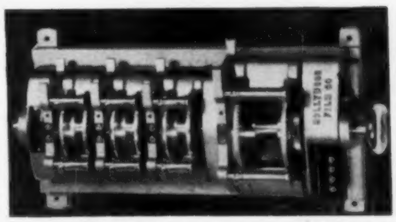

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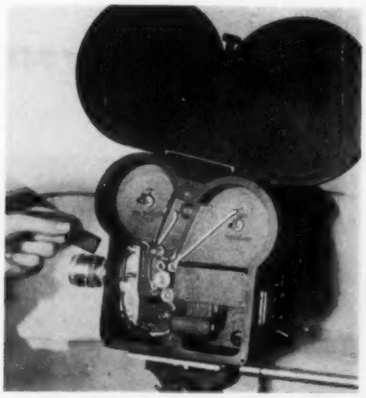
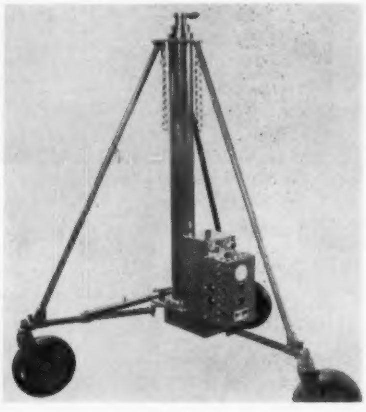
A new remote-control Zoomar lens with a zoom range of 6 to 1 and a focal length of 20mm to 120mm is being offered by Zoomar, Inc., Glen Cove, N.Y. The new lens has a speed of $f/3.9$ and is constant over the entire zoom range. It weighs about $1\frac{1}{2}$ lb, making it easy to mount with the standard "C" mount with which it is equipped. Resolution is reported better than 600 TV lines, and contrast rendition is adequately balanced over the entire spectral range of the vidicon tube. Accessories include a motor drive unit, approximately $6 \times 5 \times 2$ in., which works with miniature d-c motors and is energized from a power control unit which can be located in a remote spot. The power-control unit, approximately $6 \times 4 \times 2\frac{1}{2}$ in., consists of the necessary electrical components and spring-returned toggle switches for distance setting and zooming. A remote iris control with an additional switch is available. Basic price for the lens without the power-control unit is $700.

The Giraffe Camera Crane has been announced by S.O.S. Cinema Supply Corp., 602 W. 52 St., New York 19; and 6331 Hollywood Blvd., Hollywood 28. Hydraulically powered and operating independently of the truck or chassis on which it is mounted, the platform may be raised to a height of 40 ft. It supports a load up to 450 lb. The platform may be rotated continuously or intermittently through 360°. Dual controls permit operation from the ground or the platform. Four foot pedals and a knee-operated lever allow the cameraman aloft to control all boom movements.



A Conversion of the Cinevoice 400 has been announced by **Florman & Babb,** 68 W. 45 St., New York 36. The conversion does not cut the head off the camera or use auxiliary motors. A special needle-bearing takeup system and ball-bearing shafts fitted to the 400-ft magazines make this possible. Other special features of the conversion are: silenced Veeder footage counter; built-in behind-the-lens filter slot, with two filter holders; headphone jack built into the camera; tripod socket re-bushed with brass insert; adaptation of either Bell & Howell or Mitchell 400-ft magazines; provision of lid for covering magazine slot in order also to continue use as 100-ft camera. The conversion, including complete overhaul and surface finishing, takes two weeks to complete and costs $345, not including the magazine.

The "Molevator" Electric Stand is a power-driven stand for large lamps recently developed by Mole-Richardson Co., 937 N. Sycamore Ave., Hollywood 38. Designed especially for use with Types 90, 170 and 450 Molarcs and Type 416 Teners, it has a maximum load-carrying capacity of 250 lb. A mechanical jack screw provides positive support, and it can be stopped immediately upon release of up or down push-button controls. A slip clutch protects the mechanism at travel limits, and the casters lock in extended position for stability. Power to the junction box supplies both the motor and the lamp through pin plug connections. The enameled steel and bronze stand folds flat for storage or transportation. Stand height range is 5 ft 1 in. to 11 ft 1 in., and full elevation is attained in 21 sec. The total weight of the stand is 188 lb.



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The Arriflex 35 Model IIA offers many advantages over other 35mm cine cameras. For example, without the Blimp and with battery-operated variable-speed motor, the Arriflex is an unusually light and easy camera to handle — ideal for location shots under the most difficult conditions — even for handheld filming. With the Soundproof Blimp and Synchronous Motor, it becomes the perfect camera for lip-synched sound — both in the studio and out.

The Arriflex 35 IIA features a **180°** Mirror Reflex Shutter for through-the-lens viewing and follow focus. A new type of intermittent mechanism with registration pin action assure absolutely rock-steady pictures in perfect register.

Many other improvements have made the Model IIA the most desirable camera in the field. In fact, every important feature you would expect in a camera designed for first rate filming has been incorporated in the Arriflex 35 Model IIA.

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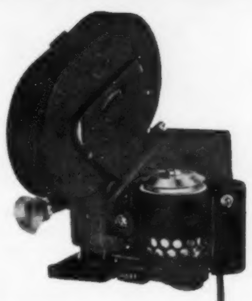

ARRIFLEX 35 Model IIA with SYNCHRONOUS MOTOR UNIT

Provides absolutely uniform and constant speed. Motor is mounted on base-plate housing containing gear mechanism which connects directly to main drive shaft of camera. Motor unit has built-in footage counter and tripod socket. Safety clutch automatically disengages motor should film 'jam'. Designed for 115-volt, 60-cycle AC operation.

ARRIFLEX 35 Model IIA in SOUND-PROOF BLIMP

Blimp housing is cast magnesium alloy, finished crackle black. Accommodates Camera, Synchronous Motor Unit and 400-foot Magazine. Internal walls are lined with corduroy velvet over six alternate layers of foam plastic and lead. Doors are sealed with foam-rubber gaskets, and close by means of heavy, 'knee-action' clamp locks. Camera is cushion-mounted.

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Brightness Spot Meter

- Checks uniformity of blue backing for matte shots directly from camera position
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- Checks color temperature of light sources to maintain uniform color quality
- Shows footcandle output of individual light units without interference from other sources
- Measures uniformity of illumination and discoloration of projection screens for any distance or angle
- Maintains standard brightness and COLOR TEMPERATURE of printer lights

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TV16 Color Test Film
Slides—TV Color
L35 Leader
L16 Leader

CinemaScope—35mm Test Films (10 items)
Visual 35mm—Picture Only
Focus-and-Alignment Section
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Magnetic—16mm Sound Only
Azimuth Alignment Test Film
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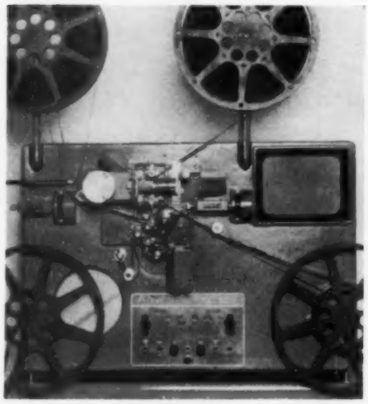
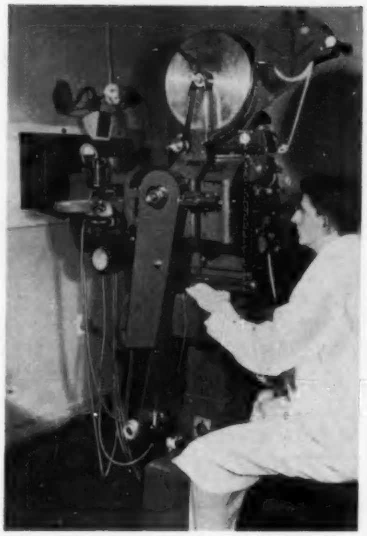


The Palmer 16mm Editing Machine is a 3-channel machine manufactured by R. Funk & Co. and distributed by M. W. Palmer, 468 Riverside Dr., New York 27. The editor has a composite film channel for sound and picture on one film, a picture channel with 5 × 6½-in. picture, and a soundtrack channel with stabilizer, sound drum and amplifier for optical soundtracks.

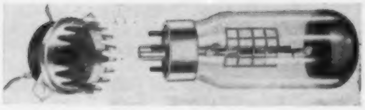
An additional soundhead for recording and reproducing magnetic sound on sprocketed 16mm film is available. Sound and picture channels can be operated separately or both can be locked in synchronism. Finger-tip controls and a color-coded panel are designed to facilitate selection of functions. Means are provided for ready film marking, and the marks show on the screen as they are made. Standardized components are used.



A new Arri Printer is part of the equipment supplied by Arnold & Richter of Munich, Germany, for a new negative-positive color processing laboratory now being put into operation by Byron, Inc., 1226 Wisconsin Ave., N.W., Washington, D.C. Designed to provide automatic fading and scene-to-scene color balancing, this printer is 35mm to 16mm and vice versa as well as 35mm to 35mm and 16mm to 16mm. This and other new equipment will be described in a technical paper at the Society's Spring Convention. Byron, Inc., has completely remodeled an additional building adjacent to the main plant to accommodate the new color processing laboratory which includes a chemical analysis section, chemical mixing room, silver reclaiming plant, and the rooms for developing, washing and drying.

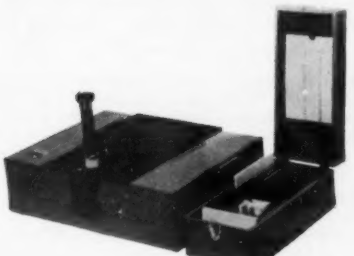
Academy Films, 800 North Seward St., Hollywood, producers of educational films for schools and motion pictures for business and industry, is building a 60 × 100 ft sound stage at the Seward St. address. The studio will be of sufficient size for the construction of almost any type of set. New grids set into concrete floor slabs will provide a new method of tying down sets.

Ripley L-R Whirlwind Blower Wheels are announced as inexpensive wheels of simplified, rugged four-pieced construction, available in stock sizes of 1-in., 1½-in., 2-in., 3-in., and $3^{29}/_{32}$-in. diameters. Special sizes can be engineered to specific requirements. Standard wheels are cadmium-plated or plain steel, or anodized or plain aluminum, while wheel hubs are supplied in standard bore sizes with one or two set screws, available in CW or CCW rotation. The L-R Whirlwind Blower Wheels are manufactured by the Ripley Company Inc., Middletown, Conn.



Sylvania Electric Products Inc. has on the market a new lamp for motion-picture and slide film projectors. Called Tru-Focus, it is only 4 in. high including socket and burns any position including horizontal or base down, thus permitting radical new design in projectors. The socket has been designed to make it possible for the lamp to snap automatically into prefocused alignment with the projector's optical system. A new grid screen has been inserted to direct air flow inside the lamp and prevent blackening in the horizontal position.

Permanently marking and coating stainless steel by a new photo-chemical process has been announced by Ateenate, Inc., 15 Chardon St., Boston 14, Mass. The integral marking, effective on metals with a minimum chromium content of 11%, is reported to produce a hard, ductile, noncrystalline structure resistant to chemical and physical damage and impervious, for instance, to heat up to 1700 F in air as well as to acids, alkalis and abrasives. It has been tested for blackening of steels, such as in guns and instrument parts and for reproducing markings and schematics on dials, gauges and panels. Markings are jet black on stainless steel or the reverse. Lines as fine as 0.001 in. can be obtained, with scales of 200 legible lines to the inch reproduced. Photographs of up to 150-screen can be made for identification badges or passports. Stainless steel sheets from 0.003 in. to plate gauges as well as rounds and shapes are used with the Ateenate process because the metal is not deeply etched.



The measurement of color with color using the Lovibond Color Scale is described in a brochure available from Curry & Paxton Inc., 230 Park Ave., New York 17, representatives for The Tintometer Ltd. In addition to the new Lovibond Tintometer illustrated above, there are Lovibond Permanent Glass Colour Standards and the Lovibond Schofield Tintometer which enables the user to link the visual Lovibond color measuring system to the official color specifications frequently expressed in the x, y and z nomenclature of the C.I.E. There are a great many Lovibond Tintometer models for the vegetable and lubricating oil industries but also some general laboratory models, including one for use where deep colors are tested. The Schofield Tintometer is adaptable to study of color emitted by cathode-ray tubes and is reported in use in England.

An Advanced Development Laboratory is being opened in April by the Radio Corp. of America at the New England Industrial Center, Needham, Mass., where Dr. Francis E. Vinal will direct advanced development work on ferrites. Ferrites, inorganic chemical compounds formed from metallic oxides, are widely used in components for television receivers, in computers, and in high-frequency applications. Product design using ferrites will continue to be done at Camden, N.J., and Findlay, Ohio.

Dr. Vinal holds a doctorate in science from M.I.T., where he majored in chemistry and where he served as an assistant professor of ceramics. During World War II, he was associated with several projects of the National Defense Research Committee. In 1952, he joined M.I.T.'s Lincoln Laboratories, and in December 1955 he went to RCA as manager of the Advanced Development Ferrites Laboratory.

A 3,000-watt slide projector, Model SP.1, has been announced by Genarco, Inc., 97-04 Sutphin Blvd., Jamaica 35, N.Y. Equipped with a 3,000-w tungsten bulb, it has a heat-reflecting filter, a 280 cu ft/min double blower, an automatic slide changer for 18 standard $3\frac{1}{4} \times 4$ in. slides, and a variety of objective lenses for rear projection of a translucent screen or front projection in large auditoriums. It is electrically tripped by the operator or by remote control with a fading effect between each projected image. With a wide-angle lens, 4,000 lm are projected on the screen, to make the projector suitable for studio backgrounds and ballroom sales presentations.

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Positions Wanted

Film Buyer or Sales. Ten years experience in industrial films. Desire position in Italy. Resume on request. Write: Fred Forma, 8798 16th Avenue, Brooklyn 14, N. Y.

Processing Lab Technician. Seven years with Kodak in Kodachrome processing stations, plus 5 years prior work in stills. Now with small N.Y.C. lab doing quality control and technical service work. Experienced in chemical analysis, solution control, printing and duplicating B & W and color, Eastman Kodak and Ansco materials, including Eastman Kodak positive-negative color, maintenance, construction, production, planning. Charles J. Gudtner, Apt. 225, 611 West 112 St., New York 25.

TV Operations Man. Knowledge of remotes. Free to travel. Desires position as studio technician. Civilian and Armed Forces radio and TV trouble-shooting experience. Knowledge of film work lab. TV Workshop and Cambridge School graduate. Write: Philip R. Smith, 2914 Gerber Place, Bronx 65, N. Y.

Cameraman—Director. Married, formerly in charge of motion-picture dept. of large metal producing company. Ten years experience in various phases of film, television and visual aids production. Desires position with organization in eastern U. S. Illustrative resume sent upon request. Vitaly V. Uzoff, 611 West 141 St., New York 31.

Audio-Visual Education. B.A. in Industrial Arts Education, formerly Instructor of Motion-Picture Photography, Signal Corps., U.S. Army. Experienced in motion-picture and still photography and TV programming. Background in electronics and high fidelity. Specialist in audio-visual methods and equipment. Complete resume upon request. William J. Ryan, Route 1, Sy Road, Niagara Falls, N.Y.

Positions Available

16mm Laboratory Technician to take over operation and responsibility of reversal processing laboratory. Must be capable of taking full charge; know emulsions and chemicals, and maintenance of Houston Model 22 machine; and capable of growing with expanding studio. Experience in printing both color and black and white desired. Write full resume, references and salary requirements to Joseph Dephoure, Dephoure Studios, 782 Commonwealth Ave., Boston 15, Mass.

Motion Picture Assistant. Need young man, graduate college-level motion-picture production course, to assist in all phases production in industrial motion-picture unit. Send complete resume and references including salary requirement to Salaried Personnel Dept., Ford Motor Co., 3000 Schaefer Rd., Dearborn, Mich.

Film Inspectors. Permanent or summer positions open. Telephone or write: Kern Moyse, Peerless Film Processing Corp., 165 W. 46 St.-New York 36.

Cameraman: Duties primarily as 16mm cameraman with some work in sound and editing. College Production unit engaged in producing 16mm color and sound films of an educational nature. Entrance salary $4320/yr. Send resume of background and experience to Norman E. C. Naill, Motion Picture Unit Manager, War Memorial Hall, Blacksburg, Va.

Writer-Editor. Duties primarily as editor and secondarily as writer. Experience in other phases of motion-picture production helpful, but not necessary. College production unit engaged in producing 16mm color and sound films of an educational nature. Entrance salary $4320/yr. Send resume of background and experience to: Norman E. C. Naill, Motion Picture Unit Manager, War Memorial Hall, Blacksburg, Va.

Motion-Picture Unit Director. An unusual opportunity for man to organize and direct a motion-picture unit. He must have experience in animation, slide films and motion pictures. He must be familiar with all types of motion-picture equipment and sources and be able to guide others in the development and execution of industrial training films. Location: St. Louis, Mo.

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Journals Available and Wanted

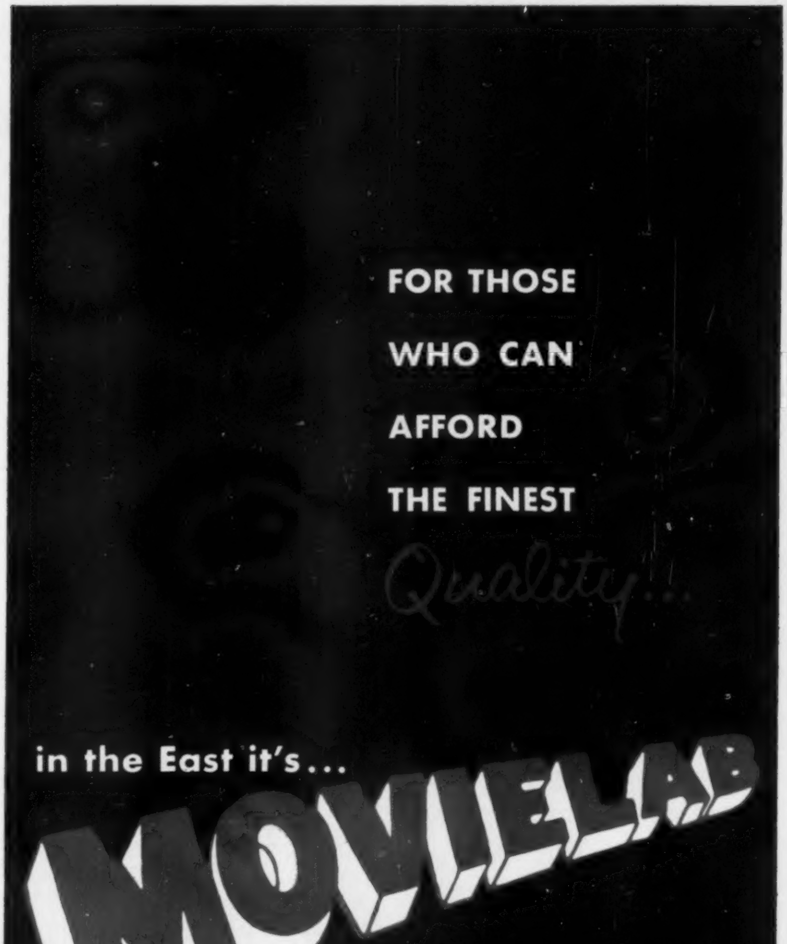
These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Available

Sept., 1937; March, 1939; June, 1939; July–Dec. 1941; 1942 through 1953; 1954 complete, with exception of Dec.; 1955 to date. Available only as entire lot. Write E. J. Mauthner, 310 Riverside Drive, New York 25.

Jan. 1930 through Dec. 1937; Journal SMPE issues; and Jan. 1930 through Dec. 1935, bound volumes of SMPE Journal; SMPE Transactions: Apr. 1919:8, May 1920:10; May 1922:13; Oct. 1922:15; May 1925:21; Oct. 1925:24; Apr. 1927:30; Sept. 1927:32; Apr. 1928:33; Sept. 1928:36; SMPE Membership Listings: 1928, 1930, 1938; SMPE Index and Authors: 1930–1935; SMPE Miscellaneous: ASA Z22—1930; Dim Stab of M.P. Films 1934; ASA Z22—1935; High Intensity Lamps—1935; Program Spring Convention Apr. 26, 1939. Write John Faber, 5 Edgewater Drive, Denville, N. J. Phone Rockaway 9-2623M.

June 1940 through Jan. 1950. Write Earle F. Orr, 345 Fellsway West, Medford, Mass.



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Dec., 1936; Jan., Feb., Apr., May, July, Sept., Nov. 1937; 1938 complete; 1939 complete; 1940 complete; Jan.-Aug. 1941. Write Richard S. Norton, Warner News Inc., 625 Madison Ave., New York 22.

Collection of back issues available either singly or as a lot. Write F. H. Cole, 1258 So. Burnside Ave., Los Angeles 19.

Complete set of Transactions and Journals 1916 to date; 61 volumes beautifully bound in black library buckram with gold-stamped backs through 1952; all subsequent issues ready for binding to match; for sales as a set only. Also for sale individually: Jan.-June 1932; Aug. 1938; Feb., Mar., May-Oct., Dec. 1941; Jan.-Dec. 1942; Jan., Mar.-Dec. 1943; Jan.-July, Dec. 1944; Jan.-Mar. 1945; Apr. 1946; Mar. Pt. I 1949; Sept. 1950; Index 1936-1945, 1946-1950; Membership Directories 1952, 1954. Write: Henry M. Lester, 101 Park Ave., New York 17.

Complete set of Journals 1938 through 1955, including High-Speed Photography volumes. Also July-Dec. 1936, Jan.-May 1937, Sept.-Dec. 1937. Entire lot $125, postage paid in U.S. Write: Gordon E. Holland, 122 Grosvenor Rd., Needham, Mass.

Complete set of Journals published previous to and including Dec. 1952, also Transactions. Write: Mort Lesser, Lesser Studio, 112 Grange Ave., Toronto, Ont., Canada.

July-Dec. 1952, Jan.-Nov. 1953, Jan.-Apr., June-July, Sept.-Dec. 1954, Jan.-Mar. 1955. Write: Omar Marcus, Vision Films Inc., 520 Royal St., New Orleans 16, La.

Dec. 1946, Feb.-Dec. 1947, 1948-1955 complete. All copies in perfect condition; for sale as entire lot only. Write: Joseph W. MacDonald, 2414 Sullivant Ave., Columbus 4, Ohio

Wanted

All Journals published in 1938 or earlier. Write John P. Byrne, Motion Picture Sensitometrics, Signal Corps Pictorial Center, 41-15 48 St., Long Island City 4, N. Y.

May, July 1944; Jan., Apr. 1945; Jan., Feb. 1946; Jan., Feb., Apr. 1947; Feb. 1950. Write Kraus Periodicals, Inc., 16 East 46th Street, New York 17.

High-Speed Photography, Volumes 2 and 3. Write William T. Mills, University of North Carolina, Dept. of Agriculture & Engineering, Raleigh, N.C.

Complete set of Transactions. Write John Flory, Eastman Kodak Co., 343 State St., Rochester 4, N. Y.

High-Speed Photography, Volumes 1, 2 and 3. Write Jack Gershon, Armour Research Foundation, Technology Center, Chicago 16.

Transactions Nos. 6 and 9. Write W. W. Hennessy, 503 West 41 St., New York.

Transactions Nos. 1, 5, 6, 7 and 9. Write Lloyd E. Varden, Pavelle Color Inc., 533 West 57 St., New York 19.

High-Speed Photography, Volume 2. Write J. H. Waddell, Fairchild Camera & Instrument Corp., 88-06 Van Wyck Expressway, Jamaica 1, N. Y.

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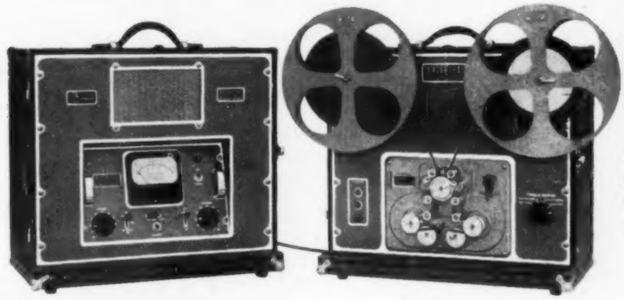

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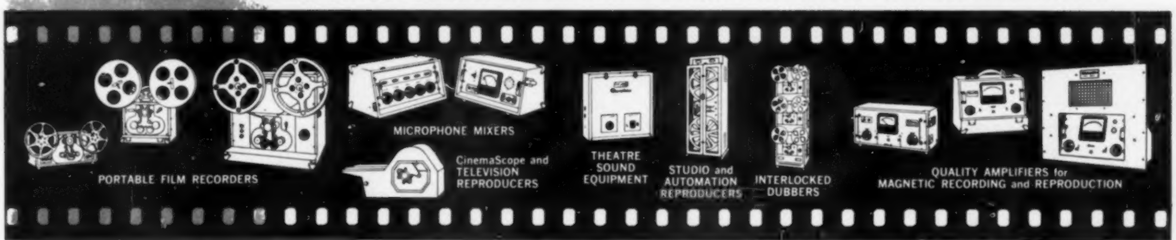

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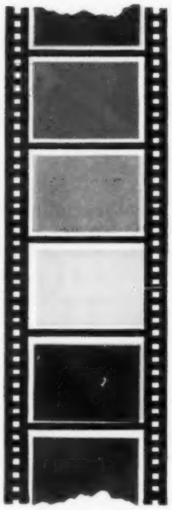

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Meeting Calendar

ASME-Engineering Institute of Canada Joint Meeting, May 23–25, 1956, Mount Royal Hotel, Montreal.

National Audio-Visual Convention, July 20–25, 1956, Hotel Sherman, Chicago.

Western Electronic Show and Convention, Aug. 21–24, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.

Biological Photographic Association, Aug. 27–31, Powers Hotel, Rochester, N. Y.

High-Speed Photography, Third International Congress, including exhibit of high-speed photographic and cinematographic equipment and instrument aids; sponsored by Britain's Dept. of Scientific and Industrial Research, Sept. 10–15, 1956, London.

American Society of Mechanical Engineers, Sept. 10–12, 1956, Denver.

Theater Owners of America, Inc., Annual Convention, Sept. 19–25, 1956, Coliseum, New York.

National Association of Educational Broadcasters, Oct. 1956, Atlanta.

National Electronics Conference, Inc., 12th Annual Conference, Oct. 1–3, 1956, Hotel Sherman, Chicago.

80th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 7–12, 1956, Ambassador Hotel, Los Angeles.

Ninth Annual Conference on Electrical Techniques in Medicine and Biology, Nov. 7–9, Governor Clinton Hotel, New York.

81st Semiannual Convention of the SMPTE, Apr. 28–May 3, 1957, Shoreham Hotel, Washington, D.C.

82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6–11, 1957, Hotel Statler, New York.

83rd Semiannual Convention of the SMPTE, April 20–26, 1958, Ambassador Hotel, Los Angeles.

84th Semiannual Convention of the SMPTE, Oct. 19–24, 1958 Sheraton-Cadillac, Detroit.

85th Semiannual Convention of the SMPTE, May 3–8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 5–10, 1959, Hotel Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members are published in the April 1955 Journal.

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